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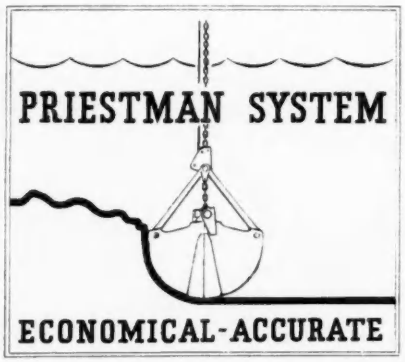

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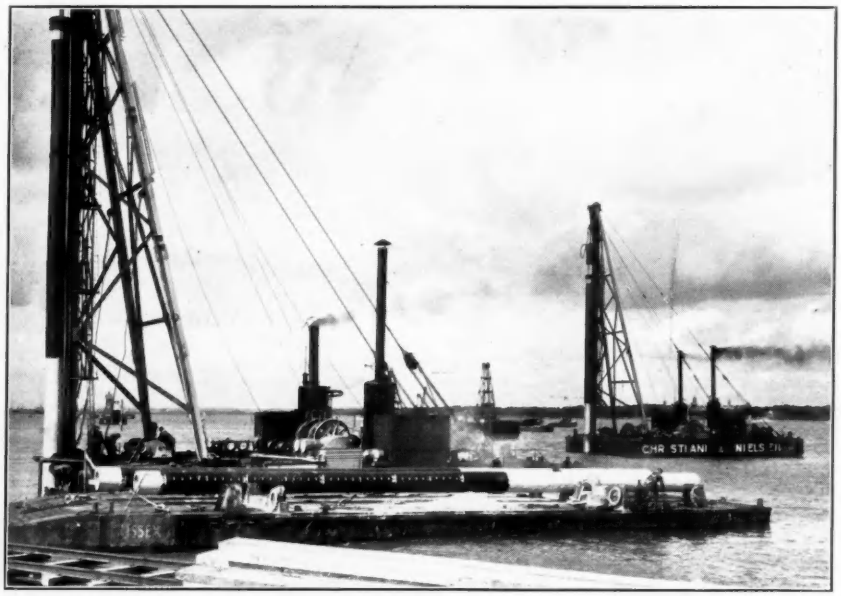

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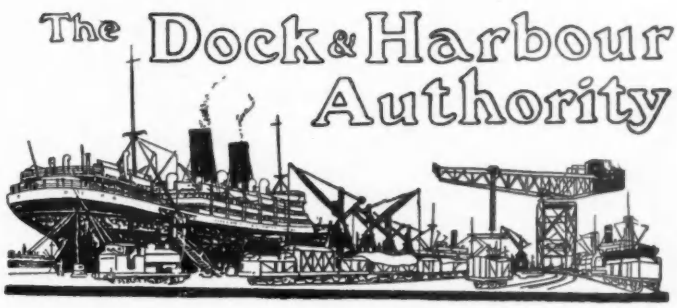

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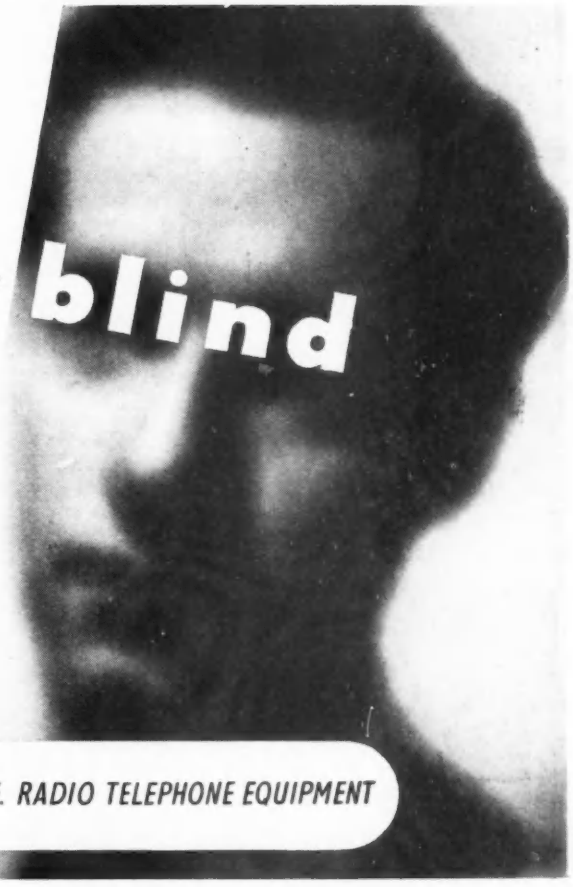

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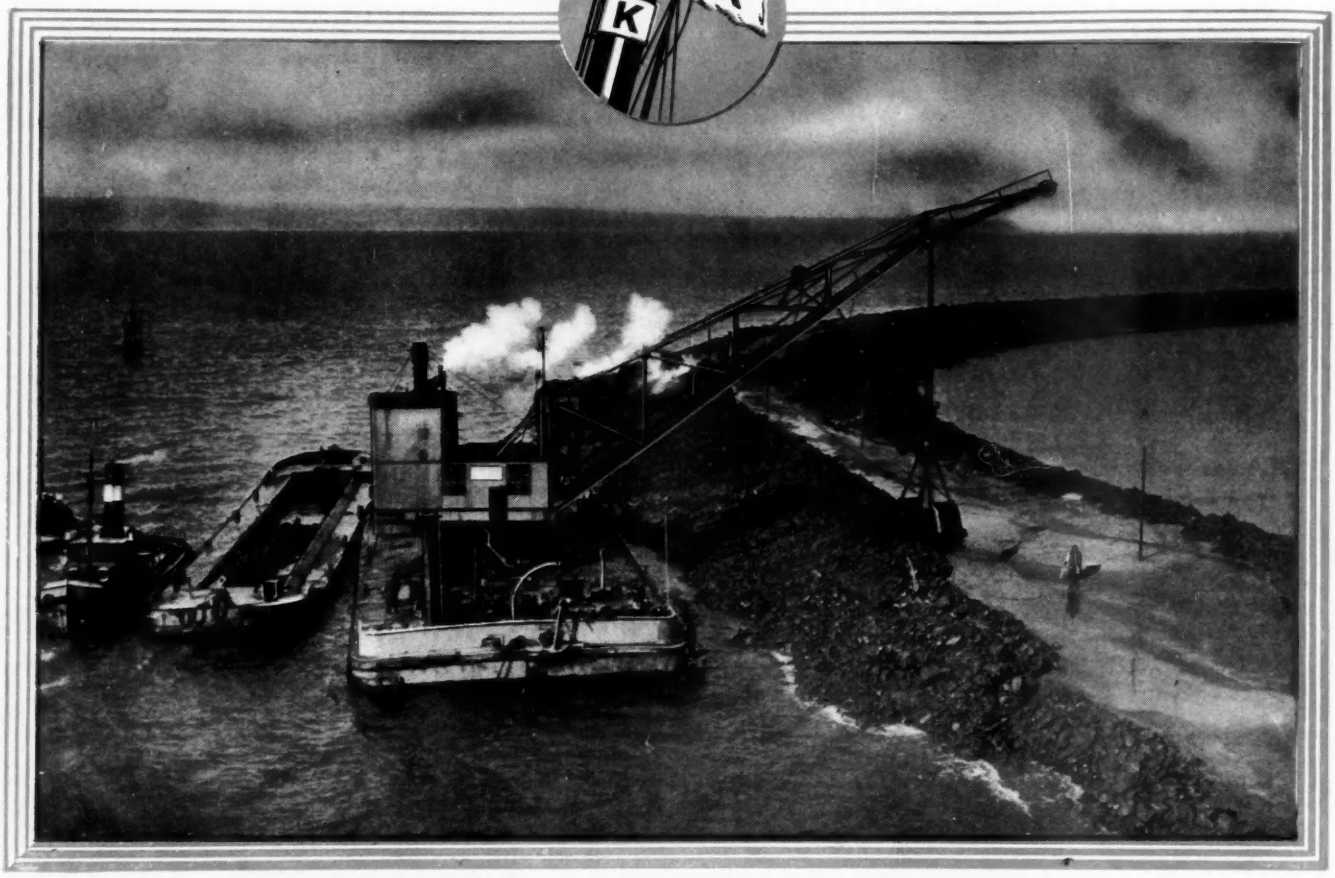

Leith Western Extension works — Breakwater under construction in 1940

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The Dock and Harbour Authority

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Editorial Comments

THE PORT OF DOVER.

Due to its proximity to the Continental ports, Dover has been one of the chief links between Great Britain and Europe, since early history.

At the time of the Roman occupation of Britain, the sea flowed up the valley of the River Dour, from which the name of Dover is derived, and a haven existed between the hills approximately where the town now stands. It was shortly after this that Dover became one of the Cinque Ports which in exchange for various privileges, provided ships and men for repelling invasion, and so can be regarded as the origin of the British Navy. Later the old haven silted up, and the modern system of docks has grown from a new harbour which was formed in the Middle Ages, on the West of the Bay. The port, with the Admiralty piers and breakwaters, now forms one of the largest artificial harbours in the world, embracing an area of nearly 750 acres.

One is apt to think of Dover Harbour in terms of the British Admiralty and the cross-channel passenger services only, but although the latter undoubtedly forms a very important part of the activities of the port, the import and export trade is also of considerable value, and in the years immediately before the War comprised some £14 million per annum. This trade is expected to have still further potentialities when the improvements mentioned on the following pages have been completed. In 1923, the Admiralty section of the port was handed over to the Dover Harbour Board, which since that date has been responsible for many improvements, in which it is interesting to note, the Town and the Port Authority have closely co-operated.

With regard to trade statistics, the Board's Statement of Accounts for the year 1950, shows that, although the figures are increasing steadily and the current year is expected to show a further improvement, they have not yet reached pre-war levels. This is due to the fact that the Harbour was taken over by the Government during the War, and on the conclusion of hostilities, the Board was left with a heavy programme of rehabilitation, which has adversely affected the revival of trade.

From an engineering point of view there are, in the recent history of Dover, works of particular interest. The construction of the Admiralty Harbour and the extensions, are well known as considerable feats of maritime engineering, and the Dover-Dunkirk Train Ferry Dock, completed in 1936, was a work which presented some difficult problems, due to fissured water bearing chalk.

A few words upon the Train Ferry Dock amplifying the information given in the article may not be out of place. The first record of a scheme for communication between Dover and France by means of a Ferry system was in 1864, when Mr. (afterwards Sir) John Fowler, who was at one time President of the Institution of Civil Engineers, put forward plans which, however, were not carried into effect. The war of 1914-1918 demonstrated at Richborough and at Calais, the great service that could be rendered by train-ferries, despite the fact that, at the British terminal, the necessary depth of water only existed at high tide.

Subsequently, therefore, powers were obtained for the construction of train ferry facilities at Dover, but it was not until 1930, after the British Government had decided against carrying out the proposed Channel Tunnel, that the Southern Railway elected to proceed with the scheme.

The ordinary methods of constructing a ferry terminal were not adopted because of the maximum range of tides of approximately 25-ft. which would have necessitated extremely long ramps and the hazardous and otherwise unsatisfactory mooring of vessels, which would be subjected to wave action and swell. It was therefore decided to berth the ferry vessels in an enclosed dock, where the water level could be raised or lowered by pumping and the dock gates could be opened and closed in practically all weathers.

The outstanding feature of the construction of the dock and its facilities, was the fact that, although the geological formation of the sea bed at the site consisted of the lower grey chalk, and previous works in the vicinity revealed its apparent homogeneous character, fissures actually existed through which it was impossible to exclude sea-water from entering the site, so that instead of the works being constructed in the dry, as anticipated, every yard of concrete below low tide level had to be placed under water.

EDUCATION SCHEME FOR PORT WORKERS.

On another page will be found a brief resumé of the aims and objects of an educational scheme for port workers, which has been formulated as a result of discussions between the Ministries, Port Executives, Trade Unions, Education Authorities and other bodies associated with the industry. The object of the Conference was "the promotion of study of the main essentials of ports and port working, their problems and background."

Dock engineers, draughtsmen and other technical employees, accept, as a matter of course, the necessity of continual study of all subjects connected with their work, in order to keep their knowledge up-to-date; they accomplish this by attending professional institutions or technical colleges and by studying technical literature. It is now realised that the same need exists in the case of the other members of a port organisation, many departments of which have of recent years become highly specialised. Indeed, in some ports, this need of a higher standard has already been recognised.

A parallel case is that of Local Government, where summer schools and other courses of study have been an accepted feature for many years, while at the present time an enlarged educational scheme is about to be inaugurated.

Editorial Comments—continued

The proposals brought forward at the recent Conference of those interested in docks should, therefore, appeal to Port Authorities and all those representing the interests of port workers, as the scheme now formulated offers an opportunity of co-ordinating and enlarging any education arrangements already in existence.

There are two incentives for advancement in knowledge, personal interest in the work, and the hope of reward, the latter being by far the greater. All non-technical grades and executive posts of a port undertaking should be attainable by any employee and the only consideration should be a man's general fitness for the job. For the success of the scheme, therefore, it is essential that the efforts and proficiency of individuals should be rewarded, and in this, the co-operation of Port Authorities is most desirable, as otherwise the response may be disappointing.

In some ports, salary levels of the rank and file are low, and there are, unfortunately, few openings for advancement and promotion. Moreover, due to loss of pension rights upon resignation, a man is largely precluded from leaving to take up a better post elsewhere, and with wages at the present relative levels, dock labourers may not be much impressed by the opportunity which is now to be offered them of obtaining supervisory posts on a port authority's staff. These aspects of employment at ports should, in our view, also be investigated. It is also probable that many dock managers will view the scheme with some scepticism, inasmuch as, generally, they may not be optimistic about the educational aspirations of port labour. Many port workers from the lower grades have, however, already forged ahead in the educational world, and their success should give an incentive to those who are anxious to improve themselves.

Another important point is that the scheme is open to all comers, and it is probable that many of the clerical and administrative workers who are anxious to widen their knowledge, but who do not want to attempt anything too ambitious in the first instance, will find the scheme provides just the right introduction to vocational study. In this connection, it is worthy of note that in Holland, in order to raise the standard of work to a higher level, the Rotterdam Shipping Federation commenced courses in cargo-handling on a practical basis in September, 1949, practical training being carried out on an old depôt ship, lent by the authorities. The Federation report that, up to the end of last year, 289 certificates of competency have been issued, the successful candidates including 231 stevedores, 38 deck-hands and 20 cargo superintendents.

We view proposals for the dissemination of knowledge for the attainment of a higher standard of port efficiency as a step in the right direction, but it is apparent that any improvement in educational standards will be largely dependent upon the assistance, co-operation and reward for individual effort, accorded by the port authorities. Even with the favourable conditions mentioned above, the success of the scheme will still be largely determined by the attitude of the port workers themselves.

BATTLE OF THE PORTS.

Under the above arresting headline the issue of " Tribune," London, for 9th February last says, "Communist-inspired troubles in the ports of Western Europe, as everybody knows, are all part of a campaign organised by the now openly Communist World Federation of Trade Unions with the avowed aim of preventing Western European rearmament, primarily by stopping the unloading and transport of American arms delivered to Europe under the Atlantic Pact. In most countries their possiblities of action are not very great, but in France and Italy, where the Communists control the major trade union organisations, the threat is serious.

" But in spite of all the Communists can do, arms are being unloaded regularly and without disturbance at many French and Italian ports—Cherbourg and Marseilles, Naples and Bari, for instance—as a result of the efforts of the dockers themselves to throw off Communist domination of their unions. To meet the Communists' international offensive, an international vigilance committee was set up by the International Transport Workers' Federation.

" The committee's technique has been to form its own ' cells ' of trusted men and gradually win the confidence of the majority of the dockers—which means usually proving that they can protect the men from Communist intimidation and violence. Beating up of non-Communist dockers was a commonplace in Marseilles until the day when the vigilance committee felt strong enough to warn the Communists that any further such attacks would be answered in kind—not by action against rank and file dockers, but against party and union officials. The warning was heeded.

" Once the reign of terror has been broken, the rest is comparatively easy. Under French and Italian law, hiring halls on the docks are controlled by representatives elected by the workers. This was the key to the Communists' control: being in the majority, they could see to it that only their own men ever got work. Now that has all changed. The extent of their defeat can be judged by the example of Marseilles, where the Communists formerly held 14 of the 55 seats on the port committee that controls the hiring halls. Since the last election a few weeks ago, they hold only ten.

" The same story is being repeated in ports all over the Mediterranean and Atlantic coasts. The battle of the ports is being won."

Unfortunately unofficial strikes are still prevalent in many other parts of the world, and for some time past, there has been trouble and unrest in Australia, New Zealand and the U.S.A. in addition to disturbances in the United Kingdom.

Dissatisfaction with acceptance by the Transport and General Workers' Union of the offer of a wage increase of 2s. a day, the details of which are given on a following page, was the cause of an unofficial strike at Birkenhead Docks which began two or three weeks ago and later extended to the whole of Merseyside, and subsequently, although to a lesser extent, affected London, where the men are pressing for the withdrawal of Order 1305—the Conditions of Employment and National Arbitration Order—which makes strikes illegal unless due notice has been given to the Minister of Labour and he has failed to act upon it. Its rescindment would leave the field clear for the agitator, although it must be admitted that, hitherto, its existence does not appear to have retarded his activities.

As the Attorney General, Sir Hartley Shawcross, stated in Parliament, the fact that so many of the unofficial strikes are directed against transport and dock organisations and the clear indication of the Communist backing of their self-appointed leaders, is one of the most dangerous factors in Britain at the present time. He maintained that the public could not be held to ransom or the laws brought into complete disrepute by illegal strikes, but he had to weigh a variety of considerations before deciding whether prosecutions would be in the public interest. This might only increase the difficulties making the prosecuted parties martyrs in the opinion of their colleagues and leading to a greater disregard of the law. He was always loath to proceed against the rank and file where the real inciters and leaders had succeeded in covering up their activities. Unfortunately those inciters and leaders are frequently acting on the best legal advice and are very successful in keeping out of trouble themselves, using the misfortunes of their dupes to their own advantage.

In New Zealand, the action of the dockers who have been on strike for wage increases since February 19th last was condemned by Mr. Holland, the Prime Minister, in a recent broadcast. He said it was " part and parcel of the world-wide cold war." The Government and the public, who were overwhelmingly workers, were tired of the dockers' behaviour. " The watersiders (dockers) have declared war on the community and the Government has taken up the challenge. The rule of law must prevail. We could capitulate to direct action, but we will not. We could let down every worker who abides by law, but we will not."

There is no doubt that wherever a firm stand is made by the Authority responsible for maintaining law and order, the plans of the agitators are frustrated; and it is to be hoped therefore, that the more sober elements, who, when all is said and done, constitute by far the greater majority, will quickly learn that they are being misled by a small unscrupulous minority, and so will resist their insiduous advances, and will not, from a mistaken sense of loyalty, give them any further support.

The Port of Dover

An Historic and Progressive Harbour

By W. TAYLOR ALLEN, M.B.E., B.Sc. (Eng.), A.M.I.C.E. and R. G. S. WILLIAMS.

THE Port of Dover, owing to its unique geographical situation as the nearest English Port to the Continent, has since earliest times enjoyed advantages never better described than in the words of Sir Walter Raleigh in his appeal to Queen Elizabeth.

" Nor is there in the whole circuit of this famous island any Port more convenient, needful, or rather of necessity to be regarded than this of Dover, in the very "streight" passage and intercourse of almost all the shipping in Christendom."

In modern times the benefits arising from Dover's geographical position, both in relation to the Continent, and as the only deep water Port between Southampton and London, are reflected in its extensive cross-channel traffic, and also in its popularity as a port of call for ocean-going vessels passing up and down the Strait.

The Port Authority is the Dover Harbour Board, which is an autonomous Public Trust and, as now constituted, comprises eight members, one appointed by the Admiralty, two by the Ministry of Transport, three by the British Transport Commission, and two by the Dover Corporation.

The administration of the Port is carried out under the direction of a Chief Executive (General Manager) assisted by a Chief Engineer, Harbour Master and Accountant, etc.

HISTORICAL NOTE

According to ancient historical writers, the regular use of Dover in connection with intercommunication between Britain and the Continent can be traced back to 300 years before the Roman invasion of this island. The latter event, however, is the earliest definite starting point for a historical survey of the actual Harbour. That Dover was the chief port of embarkation to and from the Continent in Roman times is indisputable, evidence existing to this day in the form of the " Pharos " or Lighthouse which they built on the Eastern cliffs. On the Western Heights was a similar Lighthouse, of which only the foundations now remain. These Lighthouses marked the entrance of the " haven between the hills " described in the " Commentaries of Julius Caesar." The haven, formed by the estuary of the River Dour, ran inland from under the Castle cliff.

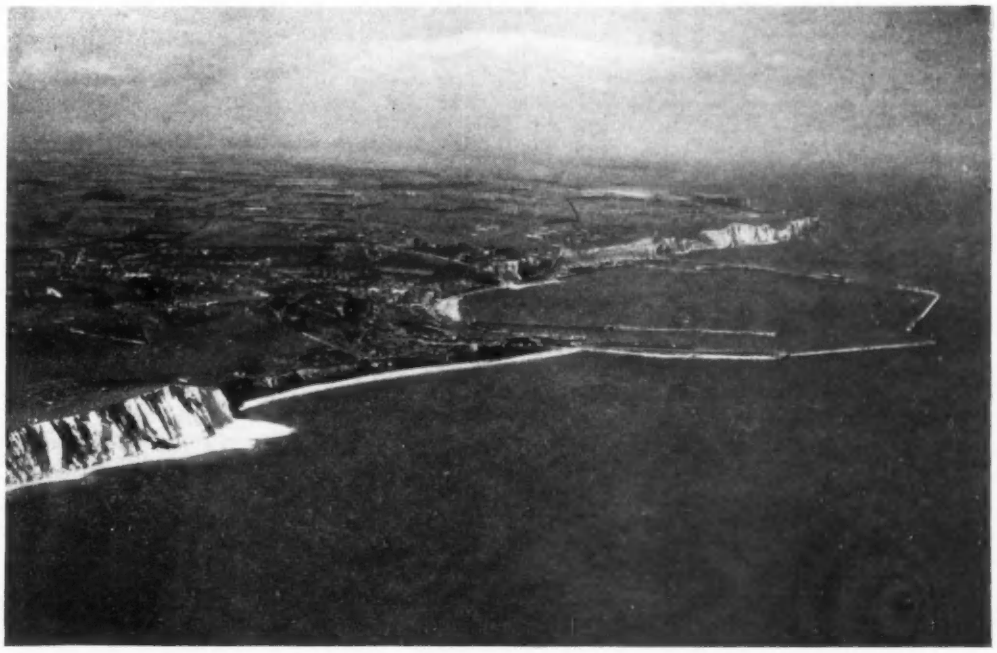
During the late Saxon period the river Dour became greatly silted and appears to have forked into two branches, the Eastbrook and the Westbrook, and the Parish of St. James was built on the delta of land formed between them. The burgesses of Dover owned a shipyard on this delta and it was here that the ships were built to " work the passage," as the Strait was then called. Twenty ships had also to be supplied for the King's Service, and were first required of the Port by Edward the Confessor. Later it became an obligation, as one of the Cinque Ports, to supply these ships in return for special privileges.

The old eastern harbour, owing to the peculiarities of tides and strong currents in the Strait, gradually became silted and, in the early part of the 16th Century a more spacious harbour was made at Archcliff Point, at the extreme west of Dover Bay. Protection from the prevailing south-westerly gales was afforded by means of a natural barrier of rock and the harbour became known as the little " Parrods " or Paradise.

Henry VIII, following his departure from Dover to meet the French King at the Field of the Cloth of Gold, ordered the building of a long pier to give added protection to the harbour. This pier was to be a continuation of the natural rocks at Archcliff Point. The construction of Henry VIII's mole was never entirely completed and, by reason of the fact that it was not built sufficiently high above low water level, it caused the formation of a long shingle bank right across the front of the town to the Castle cliff. This was the beginning of a very difficult period in the history of the harbour. for the artificial obstruction into the sea caused frequent deposits of shingle across the entrance. During the following three hundred years many schemes were put forward in an endeavour to prevent or cure this trouble, but the " battle of the bar " was not finally won until the construction of the Admiralty Pier as described later in this article.

In 1582 Queen Elizabeth appointed a Harbour Commission which condemned Henry VIII's mole, but made a real attempt towards financing a scheme to construct a harbour. Certain dues were ordered to be raised on exports of beer and grain for this purpose, and by Act of Parliament the Port of Dover was entitled for seven years to receive the benefit of dues on all British ships passing Dover, whether they used the harbour or not. This, the " Passing Tolls Act," was revived from time to time during the course of the next two centuries.

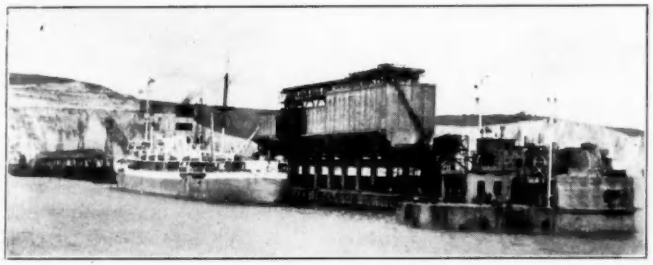
The main works projected by the Commission were the cutting of an entrance through the partially constructed head of Henry VIII's mole, and the construction of a reservoir to conserve the river water for sluicing the shingle from the harbour mouth. Both of these proposals were carried out in 1583, and the entrance so formed remains the same to the present day, being between the



[Photo Aerofilms, Ltd.

Aerial View of Dover Harbour.

The Port of Dover—continued



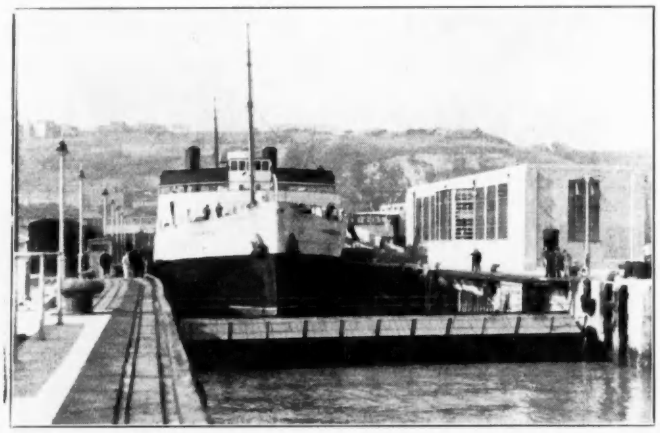
[Photo Lambert Weston

Coal Handling Plants—Eastern Arm, Outer Harbour.

North and South Piers of the Inner Harbour. The tip of the mole was left, as it was away from the entrance, and the rocks forming this head also remain to this day between the North Pier and the Prince of Wales Pier, and are known as the Mole Head Rocks. The construction of the " Great Pent " (on the site of the present Wellington Dock), between the shingle bar thrown up after the construction of Henry VIII's mole and the original beach line under the cliffs, was completed in three months at a total cost of £2,700. At this time the Harbour consisted of the original Paradise Harbour and the Great Pent, the latter being used principally for conserving water for sluicing the Harbour bar.

In 1606, by a Charter of King James I, the control of Dover Harbour was transferred from the Dover Corporation to the Lord Warden of the Cinque Ports and eleven Assistants (described as " discreet men "), who were made responsible for the administration and maintenance of the Port. They were a body corporate and operated under the title of " The Warden and Assistants of the Harbour of Dover." Critics of this Body have averred that most of its members, as country gentlemen, had little or no interest in the Town or its shipping, but, whether or not this was true, it is certain that there followed a period of deterioration and decay, during which the old Paradise Harbour gradually became silted and the land reclaimed for the building of dwellings and a few warehouses, along what is now known as Strond Street, and in the old Pier area.

To improve the sluicing capacity of the Great Pent, a further area of water was enclosed in 1718 (on the site of the present Granville Dock) by the construction of the Cross Wall, but no further attempt was made to develop the harbour until the end of the century. The North Pier was rebuilt in 1791, and thereafter for the next 50 years a series of improvements was carried out in the area now known as the Western Docks. During this period the Great Pent was rebuilt as the Wellington Dock, and a new Dock, the Clarence Dock, was constructed under what is now the Clarence Quay.



[Photo British Railways

Twickenham Ferry in Train Ferry Dock (showing Outer Dock Gate being lowered).

In 1847 the Government commenced the construction of the Admiralty Pier, which was envisaged as the Western Arm of a proposed haven of refuge to be constructed in Dover Bay. The construction of this pier, as already indicated, effectively put a stop to the silting of the harbour mouth, as it cut off the easterly drift of the shingle from the Shakespeare Beach.

In 1861 a radical change took place in the control of Dover Harbour. By a public Act of Parliament the management and jurisdiction was transferred from the Warden and Assistants of Dover Harbour (who had held control since the Charter of 1606) to a representative body of seven members, under the Chairmanship of the Lord Warden of the Cinque Ports. The Dover Harbour Board thus came into being as a Public Trust. The Lord Warden continued to be Chairman of the Board ex-officio, until 1906 when a change was made on account of the then Royal status of the Lord Warden. Thereafter, the Board have elected their own Chairman.

During the period of Lord Wardens' Chairmanship, many eminent personages presided over the Board's affairs, including such notabilities as The Right Honourable William Pitt, The Duke of Wellington, Viscount Palmerston and Lord Curzon of Kedleston.

With the coming of the railways to Dover in the early part of the nineteenth century, and the subsequent development of cross-channel passenger traffic, it was considered necessary that the larger ships, which were by now in use, should be able to enter the harbour at all states of the tide. The Dover Harbour Board therefore obtained Parliamentary powers to lengthen the Admiralty Pier and to build a long arm to the east of the Harbour approach. The estimated cost of this work was £600,000, to raise which, power was granted to levy a poll tax of one shilling on all cross-channel passengers. This new arm, known as the Prince of Wales Pier, was intended to give added protection to the Admiralty Pier berths and to provide additional landing stages for cross-channel steamers and a berth for ocean-going liners. The Pier had only been completed to three-quarters of its length (2,760-ft.) when the Government decided to build a large Naval Harbour at Dover. The plans of the Dover Harbour Board therefore had to be modified. The Admiralty Pier was widened, instead of lengthened, to accommodate a cross-channel passenger terminal (now the Marine Station), and the Prince of Wales Pier was completed to a greater length by 200-ft. and turned less to the south-west than had been originally proposed.

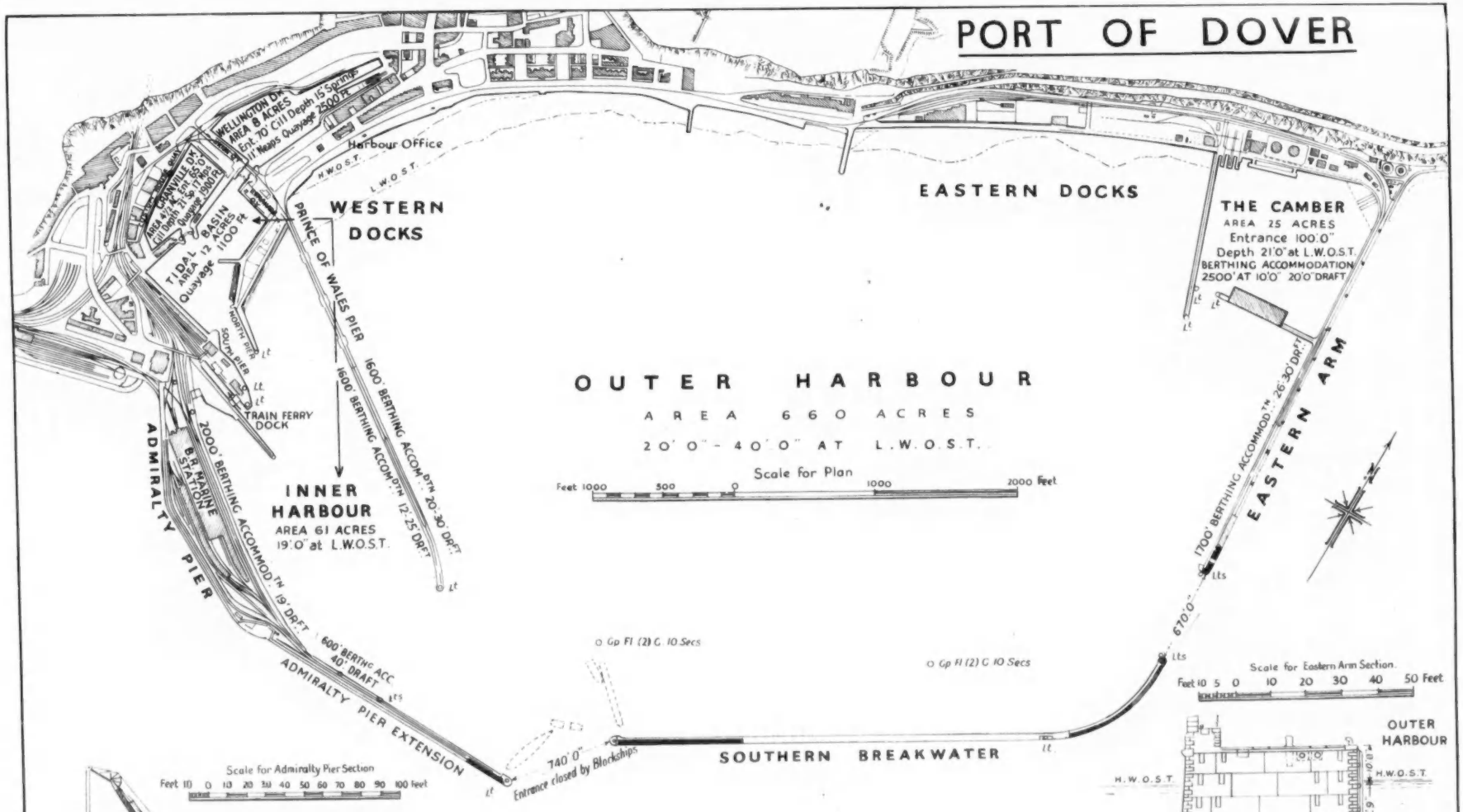
During the latter part of the nineteenth century it was found possible to improve the existing piers and quays, deepen the harbour approaches, widen the Wellington Dock Entrance and finally to reconstruct a second Dock, which was named after the Earl of Granville.

The building of the Admiralty Harbour, generally acknowledged as one of the greatest feats of marine constructional engineering of its time, was begun in 1897 and completed in 1909, and for several years thereafter the Port of Dover operated as two distinct undertakings, Naval and Commercial. In 1923 the Admiralty Harbour (now known as the Outer Harbour) was transferred to the Dover Harbour Board by Act of Parliament, the remaining areas now comprising the Eastern Docks being handed over six years later.

THE PORT OF TO-DAY

The gradual development of the Port throughout the centuries has produced the vast artificial harbour of to-day with depths of water up to 32-ft. L.W.O.S.T., and embodying accommodation for shipping of various types, up to vessels of 6/7,000 N.R.T. The Port Authority is in the happy position of having ample scope for provision of further accommodation. The total area covered by the Undertaking approximates 850 acres, including 700 acres water area. The outer moles or piers of the harbour are over two miles long and these, together with the inner walls, jetties and Sea Front retaining wall, total over eight miles of tidal wall. The water areas of the Port are divided into the Outer and Inner Harbours, and the Docks and berths generally, with their adjacent land areas, fall under two main divisions, namely, the Western and Eastern Docks.

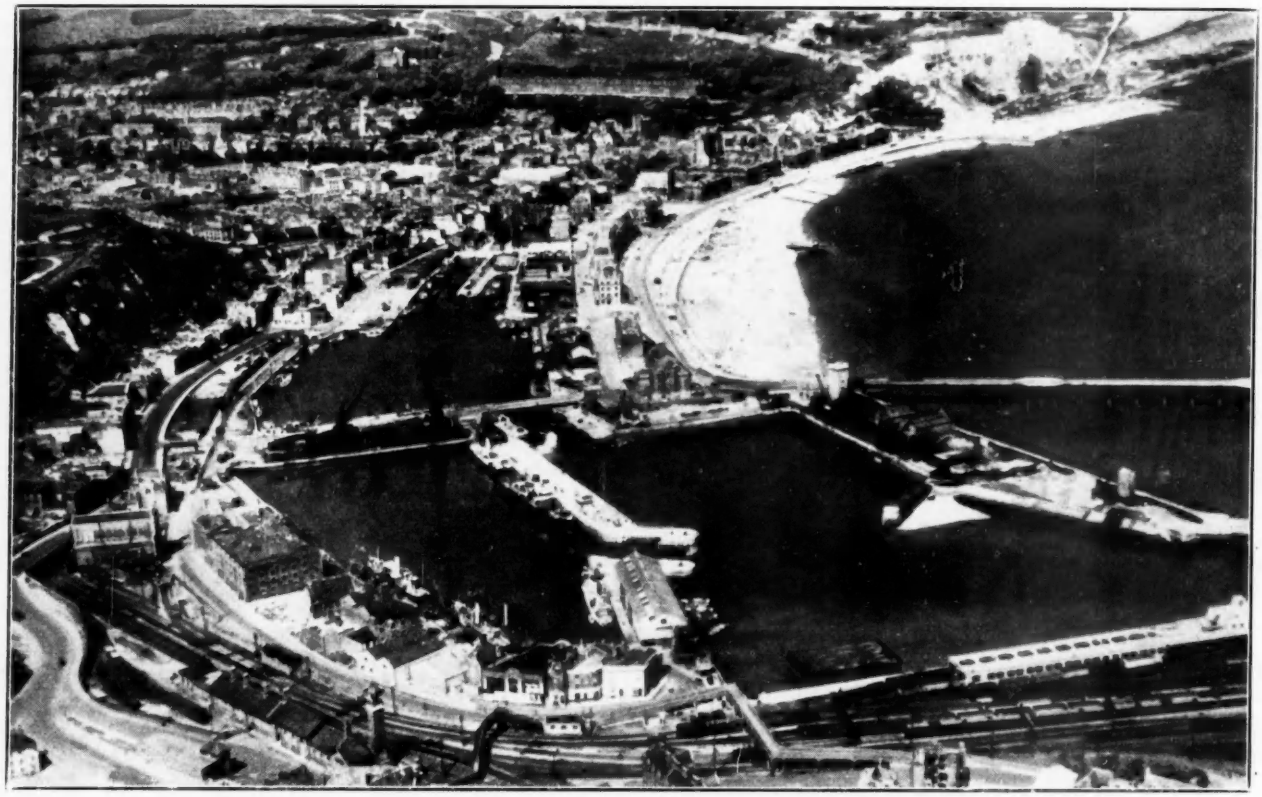
PORT OF DOVER



ADMIRALTY PIER — SECTION AT MIDPOINT OF RECLAMATION.

EASTERN ARM
TYPICAL SECTION NEAR SOUTH HEAD.

The Port of Dover—continued



Inner Docks and Tidal Basin. [Photo Lambert Weston

THE WESTERN DOCKS:

The Admiralty Pier, which is 4,140-ft. in length, was built during the years 1847—1871 and 1897—1901, and is the arm which protects the harbour from the west. The British Railways' Marine Passenger Station immediately adjacent to the Pier was built just before World War I by the then Southern Railway Company, on land reclaimed and leased to them by the Dover Harbour Board. Cross-channel passenger traffic to France and Belgium, operated by the British Railways, and French and Belgian Marine Administrations, is almost entirely handled in this area. There are five deep water berths.

Adjacent to the Admiralty Pier is the British Transport Commission's Train Ferry Dock, built during the years 1933—1936 on land leased from the Board. This Dock, which can be entered at any state of the tide, is provided with double gates electrically controlled in order that the Ferry may be levelled with the shore track to enable trains and coaches to run straight on board.

The outer walls are constructed in specially keyed concrete blockwork built up from the levelled chalk sea bed, every course being cement grouted at the outside faces. The dock bottom was formed of concrete placed in the wet to seal the highly fissured chalk in this area. Two box type steel self-ballasting gates are employed. These are each designed with their bottom seal and fulcrums in line at sea bed level, the outer gate folding down into a recess in the sea bed and the inner gate folding down into a recess formed into the dock bottom. These gates are 47-ft. high by 76-ft. wide and operated by electrically driven winches through wire tackles. They are capable of being opened and closed in a few minutes. The use of two gates permits of easy balance of pressure on their faces, utilising the gap between for this purpose. In addition one gate at the time may be entirely removed for maintenance repair purposes without placing the dock out of commission. Levelling of water in the Dock is provided for by a range of 24-in. diameter electrically driven centrifugal pumps housed in the Pump House immediately adjacent to the dockside. The link span between the shore and the stern of the ship has two rail tracks, is slung in a portal, and so compensated to admit to the list of the ship as trucks or coaches are loaded or discharged. Outside the normal adjustment obtained with the link span the rise and fall of the ship is cared for by pumping water to the required level in the Dock.

The Prince of Wales Pier separates the Inner and Outer Harbours and is 2,960-ft. long with 1,600-ft. of berthing accommodation, at which vessels of up to 25-ft. draft can be accommodated.

The Tidal Basin, which has an area of 12 acres, forms the entrance to the Granville and Wellington Docks and, although partly drying out at low water, has two useful working berths for vessels up to 14-ft.

The Wellington Dock is a non-tidal basin and has eight acres of water, with depths of 15-ft. at spring tides and 11-ft. at neap tides. The width of the entrance is 70-ft. and the depth of water on the cill at H.W.O.S.T. is 15-ft.

The Granville Dock is also non-tidal, and though smaller than the Wellington Dock, is more modern in construction and has deeper water. It consists of 4¼ acres of water, the depth being 23-ft. at spring tides and 19-ft. at neap tides. The width of the entrance is 65-ft. and the depth of water on the cill at H.W.O.S.T. is 21-ft. A pair of new electrically controlled gates were installed in 1946.

Electric or steam cranes, warehouses, and excellent road and rail connections are provided at these Docks for the quick handling and storage of general cargoes. There is also ample open storage ground.

THE EASTERN DOCKS:

The Eastern Arm is the Pier which protects the Harbour from the east and was built between the years 1900—1909. It is 2,800-ft. long and has three deep water berths, giving 27-ft. at L.W.O.S.T. Bunkering facilities for both coal and oil are provided, and steam locomotive cranes are also available alongside the berths.

The Camber is a tidal basin divided from the Outer Harbour by the South and West Jetties. It has an area of 25½ acres and a

The Port of Dover—continued

depth of 21-ft. of water at L.W.O.S.T. with berthing accommodation of 2,500-ft. at drafts of 10-ft. to 20-ft. At present the Camber is used for the Car Ferry traffic operated by Messrs. Townsend Bros., Ltd.; the G.P.O. Submarine Cable Depot is also situated in this area.

The Outer Harbour is an area of water of some 586 acres, with depths of up to 32-ft. at L.W.O.S.T. There are two entrances, Eastern and Western, but it should be noted that the Western Entrance is temporarily closed pending the removal of blockships placed there during World War II. Work on the removal of these blockships is in progress.

Good anchorage is afforded for ocean-going vessels and passenger tendering facilities are provided by the Dover Harbour Board.

The Southern Breakwater, or detached Mole, which is 4,270-ft long, protects the Outer Harbour from the open sea and was built between the years 1904 and 1909.

GENERAL FACILITIES:

Crane facilities at cargo berths include five, eight and ten-ton steam locomotive cranes; 35 cwt., three, five and ten-ton electric cranes; 2-ton mobile cranes, and a 25-ton floating self-propelled crane.

Bunkering points for fuel and gas oil are provided on the Eastern Arm and on the West Jetty, and are operated by the Shell-Mex and B.P. Company, Ltd., from their Installation in the Eastern Docks. Coal bunkering is also dealt with at the Prince of Wales Pier, the Eastern Arm and in the Western Docks.

The Board's Steam Tugs, 1,600 I.H.P. " Lady Brassey " and 650 I.H.P. " Lady Duncannon," are on call day and night for towage or tendering. A further Tender is shortly to be provided. These Tugs are well known in shipping circles for the excellent work they have carried out in the salving of many vessels in the English Channel, particularly from the Goodwin Sands. During the recent War these services were vitally important and carried on under great difficulty through constant enemy cross-channel gunfire.

A patent slipway, capable of taking small vessels up to 175-ft. in length on a draft of 13-ft. and up to 800 tons deadweight, is operated by the Board in the Wellington Dock.

Fresh water supplies are obtainable at all berths in the Outer and Inner Harbours, and Docks. Vessels at anchor are supplied by the Board's Tugs.

Experienced divers are available for carrying out minor repairs.

TRADE OF THE PORT

Dover being the nearest English Harbour to the Continental Ports of Calais, Boulogne, Ostende and Dunkirk, the principal trade is naturally cross-channel traffic, including passengers, accompanied cars and cargo. The Port deals, however, with a variety of other trades. In an average year 6,000 vessels with a net registered tonnage of 3,800,000 enter the Port, carrying up to a million passengers and 600,000 tons of cargo. Passengers embark or disembark from British, French and Belgian vessels, and in the height of the season there are as many as 28 cross-channel sailings and arrivals daily. The greater proportion of passengers are dealt with by the British Railways at their Marine Station, where a highly efficient service is maintained in the transfer of passengers and their luggage, mails, etc., from train to ship and vice-versa with the maximum speed and comfort. The boat trains cover the distance between Dover and London in 1 hour 35 minutes.

The Train Ferries which ply between Dover and Dunkirk from the British Railways' Ferry Dock are capable of carrying 12 sleeping coaches, or alternatively 32 vans, on the train deck, with approximately 30 motor cars under cover on the top deck. There is ample accommodation for ordinary passengers. Passengers travelling by the Night Ferry need not be disturbed after boarding their train in London until their arrival in Paris the following morning. In the day-time the train deck is used for carrying cargo or cars, the annual tonnage carried (inclusive of cars) being about 250,000 tons. The three specially constructed Train Ferries are named the S.S. " Hampton," " Twickenham " and

[Photo Lambert Weston
Train Ferry Dock (showing Link Span in loading position).

" Shepperton " Ferries. Two of the vessels are operated by the British Railways and one by the French. A fourth Ferry is to be introduced to the Service during 1951.

During an average year some 200 ocean-going passenger vessels enter Dover, including ships of the Royal Netherland S.C. Co.; United Netherlands Navigation Co.; Bullard and King; Holland-Africa Line; Elder Dempster Line; The Blue Star Line; Olsen Line; Lamport and Holt Line; Transatlantic Rederi Co., Sweden, and United African Line, on their outward and return journeys to the West Indies, Madeira, South and West Africa, Scandinavia and Australia, and are tendered in the Outer Harbour by the Board's Tenders.

The cargo tonnage handled annually at the Port approximates 600,000 tons, imports and exports, consisting of general cargoes, motor cars, coal, stone, grain, timber, pit-props, oil and fruit.

Under normal conditions the cargo trade of the Port includes the export of Kent coal, and two Bunkers with loading equipment are situated at the Eastern Arm for this purpose. One of these Bunkers is now vested in the National Coal Board (late Tilmanstone Collieries) and has a capacity of 5,000 tons, being filled by skips brought by aerial ropeway direct from the Colliery, some seven and a half miles away, at the rate of 120 tons per hour. From the Bunker the coal is conveyed, weighed and loaded into ships at the rate of 500 tons per hour. The second coal handling plant, owned and operated by the British Transport Commission, consists of a wagon tipler plant, conveyor belts and loading arms, delivering coal at the rate of 500 tons per hour.

[Photo Lambert Weston
Unloading Cargo at Granville Dock.

The Port of Dover—continued

Cross Channel Vessels at Admiralty Pier. [Photo Lambert Weston

Within the Board's industrial estate several factories and other businesses are operated, including a Fountain Pen Factory, Metal Foundry, Ship Breaking and Scrap Metal Concern, Road Metal Manufactory, Ship Repairing and other Workshops. The British Railways also operate a Workshop for the overhaul of their cross-channel vessels and the Board maintain their own Workshops. The sites afforded are attractive and well provided with facilities and services. There is ample room for expansion.

The Board are also owners of a considerable number of residential and hotel properties in the Sea Front area, erected on land which is held by them for potential Harbour development.

PORT DEVELOPMENT

The extensive damage suffered by the Town and Port of Dover during the War, unfortunately calls for the re-building of large areas and the Authorities have wisely taken the opportunity to re-plan certain areas where devastation permits of such a course being taken. The Town and Port Authorities have closely co-operated where their interests converge.

The immediate development which is receiving the attention of the Port Authority is the improvement of facilities in the Inner Docks (Western Docks area). Clearance is being made of obsolete buildings immediately adjacent to the quays in the Wellington and Granville Docks to provide greater accommodation for cargo handling. Railway sidings and road access to the quays are being improved to avoid congestion of traffic at the quayside.

Custom House Quay, Granville Dock, is the first quayside to be completed in the new development, and is now provided with excellent road and rail facilities, together with high-speed electric portal cranes. The adjacent areas have been levelled to form ample storage space and further clearance is in process of completion. Additional warehouse accommodation has been provided, and will be extended as required. The other quays are being entirely re-planned to make full use of the available space and provide new working areas.

The main projected development in the Eastern Docks is the provision of an up-to-date Car Ferry Terminal for the handling of accompanied vehicles, construction of which it is anticipated will commence early in 1951, at an estimated cost of half a million pounds. At the present moment the transport of accompanied cars is dealt with at three places in the Port :

(1) From the Admiralty Pier, where cars are loaded by crane on to Car-ferrying Vessels.
(2) From the Train Ferry Dock, where cars and coaches run straight on to the Train Ferries.
(3) From the West Jetty, Eastern Docks, where cars and coaches are loaded by crane on to Messrs. Townsend Bros. Car Ferry.

The present arrangements are not satisfactory, particularly at the Western Docks where the facilities employed were originally laid out for handling passenger traffic. Parliamentary powers have therefore been obtained for the construction of an enlarged Car Ferry Terminal, sited in the Eastern Docks, which, when completed, will cater for the cars now being dealt with under (1) and (3) above.

The Car Ferry Terminal is being planned to allow for the speedy handling of motor cars by means of stern loading ramps to vessels. Quick transit will be assured by the provision of facilities for dealing with the various shore formalities, together with good road access to the Town. There will be adequate reception accommodation, including Operating Companies' Offices, Buffet, Restaurant, Post Office, Waiting Rooms and Car Parks. New jetties will be constructed to improve the berthing arrangements of the Car Ferries. At the heads of these jetties, which are liable to heavy wear and tear during berthing operations, a special form of protection will be provided in the form of a rotating steel and concrete constructed bell which is designed to turn and recede under impact, thereby giving a gentle braking action. The vertical faces of these bells are to be fendered with hard wood wearing timbers. Special stern buffer fenders are also to be provided, namely, two at each Portal. Each fender will consist of a vertically hung rectangular steel and timber frame with a Flemish Elm wearing face, supported by chains and backed by 15 spring buffers similar in appearance to the ordinary locomotive buffer. Each of these spring buffers will take a load of 50 tons when compressed through a distance of 16-in. In addition to absorbing the load by means of the spring buffers, part of the energy of a ship striking will be taken by the vertical lift of the whole frame. Two berths will be provided parallel with the West Jetty and the loading bridges will be suspended at their seaward end from concrete portals and be capable of vertical movement controlled either by hand or automatically following the tidal variation. The land arrangements include the main Customs Examination Building, which has been designed to deal with 240 cars comfortably in an hour, travelling inwards and/or outwards.

The transhipment of accompanied cars has been regarded by all parties concerned as one of the most important factors in the future of the Port. Before World War II the number of cars passing through the Port was increasing annually and the numbers have continued to increase since the War, reaching in 1950 the figure of 93,000 cars. There is no doubt that this figure will be considerably exceeded with the completion of the new facilities.

The Train Ferry Services, carrying passengers and cargo in through railway coaches and wagons, is another trade which is likely to expand rapidly and has already reached the stage where development is under consideration.

The Port of Dover has, besides its natural advantages, considerable undeveloped potentialities which the Port Authority has well in mind. With the completion of the improved facilities and development of Dock areas now visualised, it is confidently anticipated that Dover will continue to hold its place as the major trading Port between London and Southampton, and also to maintain its privileged position throughout the ages as the " Gateway to England."

NEW GRAVING DOCK FOR PORT OF DUBLIN.

Dublin Port and Docks Board are to construct a new graving dock capable of taking ships up to 18,000 tons d.w., instead of the 8,000 tons maximum of the present dock. The contract, which amounts to over £890,000, is the largest ever placed by the Board, and was awarded last month to the Irish Construction Co., against world competition. The new dock will be 630-ft. long and 80-ft. wide, and will accommodate the largest ships which normally visit the port. The Government of Eire has agreed to contribute £500,000 towards the cost, and construction is to begin almost immediately. The scheme will provide work for 300 men for three years, and it is hoped its completion will play an important part in the development of the local shipbuilding industry.

Sea Transport of Bulk Cargoes

Handling and Transhipment Equipment for Heavy Industries

By G. A. WHITTON
Vice-President, The Maritime Services Board of N.S.W.

(continued from page 303)

In the February issue of this Journal, we published the first instalment of a paper entitled "Port Administration in New South Wales, with particular reference to Port Kembla," by Mr. G. A. Whitton, which he delivered before the Port Kembla Branch of the Australian Institute of Metals on the 17th May, 1950, and in this issue we are publishing the second instalment of the same paper, which deals specifically with sea transport and bulk cargo handling in connection with heavy industries.

In introducing the second part of his paper Mr. Whitton said that the handling and transhipment of bulk cargoes is an intricate and interesting business which involves the use of special equipment both in the form of ships and handling gear. It is beyond dispute that, to obtain the most satisfactory results, special ships and special equipment designed for the particular services must be provided.

SPECIALLY DESIGNED VESSELS

In the case of vessels for trade of this nature, it is essential to have specially designed holds of suitable size and strength, clear of obstructions and planned so as to eliminate trimming or reduce such work to a minimum. The hatches must be well placed and sufficiently large to give adequate access for loading or discharging gear. There are some vessels on the Australian coast which have been specially designed for the carriage of bulk cargoes. I have in mind particularly the new vessels built by the Broken Hill Pty. Co., Ltd. for the ore trade and one or two colliers.

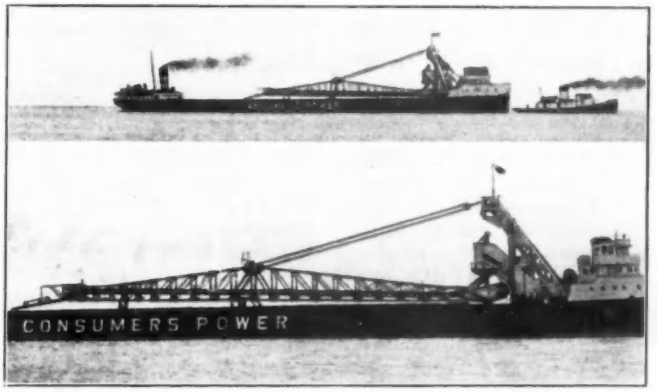
Probably the greatest development of vessels for use as bulk carriers has taken place on the Great Lakes system in the United States of America, and during a visit to the States several years ago I was fortunate to see a considerable number of this type of vessel in operation and to see also the special bulk-handling equipment which has been installed at the principal ports and heavy industry centres in that area. Many of these vessels are up to 620-ft. in length, with a beam of 60-ft. or more, but they are of restricted draft, perhaps about 22-ft. They have been designed to provide the maximum effective use of the unloading equipment at the point of discharge, the ships being built to provide continuous holds without interruption by superstructure. Engines and part of the superstructure are located aft and the bridge and balance of the superstructure are on the forecastle head, the space between being divided into larges hatches, up to 20 in number, with very low coamings. The cargo capacity ranges up to 15,000 tons.

SELF-UNLOADING VESSEL

A fairly recent development of particular interest is a type of bulk carrier which discharges the cargo with the vessel's own mechanical conveyor gear. These ships mostly handle coal, which is discharged to stock piles on shore by the use of a heavy unloading boom which may be up to about 240-ft. in length. I saw one of these ships in operation at Milwaukee where the coal was being discharged into heaps about 150-ft. from the river frontage by means of a belt conveyor arm suspended from an "A" frame erected immediately behind the forecastle head. The holds of the vessel are in the form of a number of steel hoppers and under the floor of the holds there are two tunnels which run fore and aft the full length of the ship. The cargo of coal is admitted through a number of openings in the roof of the tunnels to conveyor belts which carry the coal to a bucket conveyor which elevates it to the conveyor arm. This particular ship was discharging at the rate of 1,500 tons per hour, but I was informed by her officers that more modern vessels specially built for this type of operation had reached a discharging rate of 1,800 tons per hour. During the discharging operations the vessel is moored at the berth with wires which are left on the winch drums to facilitate movement of the vessel and boom as the coal is piled on shore. By this means the cargo can be discharged a considerable distance beyond the face of the wharf or river bank. The great advantage of this is that the whole of the ship's cargo is discharged without employment of shore labour, the mechanism on board the ship being controlled by a limited number of the ship's personnel. This system results in a vessel being able to not only discharge continuously throughout the stay in port but allows an immediate start on arrival.

NEWCASTLE HARBOUR

At Newcastle special facilities in the way of gantries with a high output, and special equipment for loading coke, have been provided at the wharfage of the Broken Hill Pty Co., Ltd. for handling inward consignments of ores, limestone, etc., and for loading coke. Coal is loaded by means of cranes which lift the bottom-discharge hopper trucks over the vessel's hatches, the electric cranes having a maximum loading rate of 90 to 100 tons per hour and the hydraulic cranes from 80 to 90 tons per hour, which, of course, is slow compared to some coal-loading overseas, particularly in the U.S.A.



Self-unloading Steamer seen at Great Lakes, Milwaukee, U.S.A. Capacity 8,500 tons of coal, ore or stone. The lower picture shows the beam used to discharge overside up to a disance of approximately 150-ft.

WHYALLA

At Whyalla a special jetty has been provided for handling iron ore which is taken to the outer end of the jetty by a series of belts for discharge through chutes into the holds of vessels. A loading rate of up to 1,500 tons per hour is obtained with this system.

BULK HANDLING

In the earliest days of bulk material handling it was the practice to unload cargoes by shovelling the material into tip buckets which were then raised and swung ashore with the vessel's own gear. In many cases the next development was the use of cranes for unloading material from barges or vessels and in this operation the bucket picks up its load from the hold, swings through an arc and deposits the material into a receiving hopper or ground storage. An improvement on this system is the use of level luffing cranes with grabs in which a rapid vertical movement of the jib brings the grab into the shore after the vertical lifting operation. The release of the correct amount of rope during the movement of the jib keeps the grab at the same horizontal level while moving inward to the hopper.

Sea Transport of Bulk Cargoes—continued

The average rate of handling with unloading towers, as well as with many other types of equipment, depends a good deal on variable factors including the nature of the vessel and its holds, the height of the lift from the hold, and the number of times the ship has to be moved. Where trimmings is necessary from time to time as unloading operations progress, this is another factor which governs the rate of discharge and similar considerations apply in the case of loading bulk cargoes into a vessel. Generally speaking, the highest rate of discharge of bulk cargo occurs at the start of the operation when there is a period of so-called "free digging." As unloading progresses the rate generally slows down because of the increasing height of lift from the hold, the necessity to shift from hold to hold, and, with some vessels, the need to trim cargo to a point where it can be reached by the grabs or other equipment.

The general tendency in the design of unloading towers where heavy tonnages are involved is towards the construction of larger units as it is claimed that the operating cost is practically the same for a large capacity unit as for a medium one. When a tower or any other movable unit is erected on piers or wharves exposed to heavy weather, it is essential that it be securely locked in position when not in use to prevent possible damage as a result of movement by wind storms. The problems encountered are essentially the same for one bulk material as another, the principal difference being in the unit weight of the substance to be handled. Where the quantities to be handled justify the additional cost, the unloading or loading gear is made to travel along the wharf the full length of a ship, the tower or other equipment propelling itself from hold to hold, thus making it unnecessary to shift the vessel during discharging operations.

GRABS

The use of the correct type and design of bucket is an important feature in bulk handling operations where a grab or bucket is employed. When dropped on to the cargo the teeth or lips of the bucket should sink into the material before any other part strikes the cargo, otherwise the force penetration of the teeth or lips is lost and partial closing of the bucket loses the advantage of full open spread. Properly designed teeth or lips assist greatly in penetrating various materials and a low centre of gravity is important to prevent the bucket from tipping over when striking cargo. As a general rule speed of bucket operation varies in inverse proportion to the closing power, and where different types of material are to be handled it is desirable that the closing power be adjustable so that maximum closing speed may be obtained under the varying conditions.

INSTALLATION COSTS

Perhaps the greatest problem to be faced in planning a bulk handling installation, is that associated with arriving at an economic balance between the cost of the installation and operation of a plant with a high capacity which it is known will only be in operation for limited periods and the much lower cost involved in the installation and operation of a plant with a comparatively low capacity which will be more or less continuously in operation. The cost involved in providing the batteries of Hulett machines at ore discharging installations in the U.S.A. is only justified by the tremendous quantity of ore handled. My own view is that these days, owing to the high cost of ship operating, it is better to err on the side of providing greater capacity than might actually be warranted.

BULK HANDLING AT U.K. PORTS

I was also privileged to see bulk handling methods in operation at certain ports in the United Kingdom as well as in the United States.

AVONMOUTH

At Avonmouth, near Bristol, ore and phosphates are discharged with grabs and 3-ton cranes into hoppers which feed to buckets on an aerial tramway which conveys the material for quite a long distance to works or to rail. Owing to the light nature of the phosphates it was necessary to use a special type of grab with steel covered bucket to prevent the material blowing about. In the case of the concentrates, it was found that when the material was loaded into the hoppers it was difficult to make it flow and it was found necessary to install electric vibrators to make the material flow out of the hoppers.

NEWCASTLE-ON-TYNE

At Newcastle-on-Tyne, iron ore and phosphates are imported, a particularly well-arranged 800-ft. berth being provided for handling such cargoes direct to rail trucks. These berths are unshedded and have a "battery" of eight 5-ton cranes with long reach for handling the cargo. The cranes can discharge into trucks placed on any of the seven available tracks on the area, and, if necessary, the whole eight can be concentrated on one ship. Ore and phosphates are discharged at between 40 and 60 tons per gang hour at this berth. Here also a special type of closed grab has been evolved for handling phosphate in an endeavour to overcome the dust nuisance. At the coaling plants at this port, 20-ton bottom-dump trucks are used and the capacity of some of the

Hulett Unloaders for discharging bulk ore cargoes, Cleveland, U.S.A.

plants is as high as 500 tons per hour. Anti-breaker is available at most plants, but is seldom used since very little household coal is handled. The plant is totally enclosed and at the tipping point a dust remover is installed. The plant is almost automatic and all movement is controlled from a cabin in the tip over the ship's hatch.

CARDIFF AND SWANSEA

At Cardiff and Swansea, as at all South Wales ports, it was noted that very extensive equipment was provided for the handling of coal. This is essentially an export trade and has required a specialised form of equipment. The installations are of two main types. In one, the coal truck is brought right up to the face of the wharf, and there elevated in a hoist and the coal truck tipped, the coal sliding down a chute into the ship's hold. In the other type, the tipping of the truck takes place some distance back from the face of the wharf, and the coal is then conveyed by means of belt conveyors to the chutes. In pre-war days a great number of grades of coal were sold and special equipment was provided to prevent breakage, but during the war this equipment has largely fallen into disuse, and coal was shipped direct to the chutes without regard to breakage. The railway tracks are so

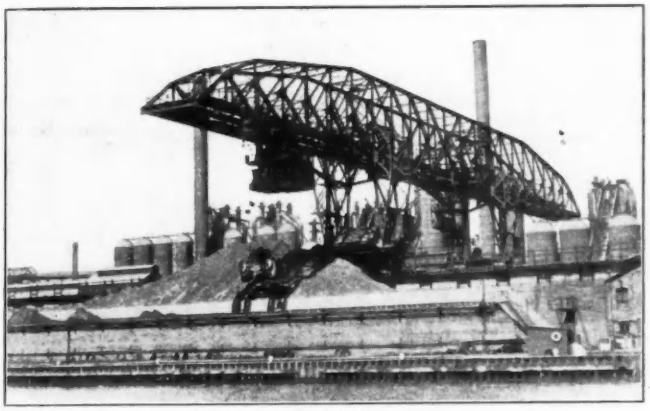
Sea Transport of Bulk Cargoes—continued

arranged that the gravity is used as much as possible, including the track to and from the coal hoist. The rate of shipment was not considered high and, with few exceptions, appeared to be no better than that obtained by the use of the cranes at Newcastle.

Generally speaking, bulk handling seen in the United Kingdom, except perhaps in the case of coal, was not of great interest. Output was not high and where an attempt had been made to increase output by the installation of improved plant, labour insisted on the retention of men who could no longer be usefully employed.

BULK HANDLING APPLIANCES IN THE U.S.A.

Some very fine equipment was noticed in the United States, particularly at the Great Lakes ports, where some of the largest plants in the world are installed for the handling of iron ore and coal. Very highly specialised forms of unloading equipment have been devised, particularly the Hulett transporters and also the ordinary straight-line transporters similar to those in use at Newcastle steelworks. It is only the very large tonnages of bulk materials which are handled at these ports which justify the heavy expenditure which has been incurred for the provision of such elaborate equipment enabling very quick handling of cargoes. Loading was found to be generally in the vicinity of 2,000 tons



Ore Unloading Plant, Illinois Steelworks, Chicago, U.S.A.

per hour, but I was informed of one case in which about 10,000 tons had been put into a ship in a period of 20 minutes, in this case the ship being held up to the quay wall by a battery of tugs. Discharge figures are also very high ranging up to 2,000 tons per hour, but somewhere in the vicinity of 1,000 tons per hour or perhaps less is the normal speed for discharging operations. The highest rates for unloading are reached when Hulett gear is employed and I saw several instances where this equipment was in operation.

HULETT UNLOADERS

The Hulett unloaders, which are becoming increasingly popular, are capable of handling ore from the hold of a bulk carrying vessel at the rate of 30 tons per minute. I saw batteries of this equipment in use at Cleveland and two machines have been installed at Toledo in the modern coal and ore handling terminal recently completed there. The authorities at that port anticipate that approximately 10,000,000 tons of bulk cargoes will be handled each year. At this new terminal there are also two coal-dumping machines each capable of picking up and dumping loaded 70-ton coal trucks at the rate of one a minute and a third coal dumper is now being added. This equipment requires very massive foundation, the Hulett unloaders weighing about 800 tons each and the coal dumpers about 1,600 tons each. It has been reported that each coal dumper is mounted on a 2,400 cubic yard concrete bed with a depth of 13-ft. resting on top of extensive timber piling. The ore machines have concrete foundations with a depth of 8-ft. resting on numerous timber piles over a length of 700-ft. with rail tracks to permit the machines to move along the length of a vessel.

BRIDGE CRANE AT MONTREAL

At the Port of Montreal one of the principal stevedoring interests has provided an all-purpose bridge crane with an unloading capacity of 300 tons per hour and an overall span of 280-ft. Of this span 190-ft. is placed over the wharf and there is a 90-ft. boom projecting over the water, enabling transhipment from a vessel at the berth to another vessel berthed outside it, as an alternative to transfer of the cargo from the ship to shore. This equipment is used to handle a wide variety of bulk products including coal, manganese ore, silica sand, phosphates and other types of bulk products. If required, coal can be screened during the loading operation, and if for any reason a commodity requires careful handling, a belt conveyor can be used for discharge to shore or to rail trucks so as to eliminate risk of breakage.

CLAM-SHELL TOWERS

Many operators in the United States claim that one of the most efficient means developed as yet for unloading bulk materials from ships is the Clam Shell Bucket Unloading Tower which is used very extensively on the North Atlantic Coast, the most important bulk material handled there being bituminous coal. With this equipment the coal is usually unloaded by an unloading tower which takes the material out of the ship's holds and delivers it to a receiving hopper within the tower from which the material is usually distributed by means of belt conveyors either to stock piles on ground storage or direct to the bunkers of undertakings such as generating stations.

EQUIPMENT AT LONG BEACH

Another type of special bulk handling equipment is in use at Long Beach for fast ship loading of any bulk product not exceeding 150 lb. weight per foot and up to approximately 14-in. in size. This terminal handles substantial quantities of coal, potash, sulphur, cements, gravel and sand at rates up to 250 tons or more per hour. In operation, bottom-discharge hopper trucks pass over a series of steel-lined hoppers which are bedded in a reinforced concrete housing below the deck level. The bulk material drops through gratings and on to shakers which move it mechanically to an endless belt conveyor which elevates it to such height in the conveyor tower as will permit it being dropped by the assembly belt conveyors and transferred horizontally to a point over the ship's hatch. From this point the cargo is dropped into the hold through a movable chute and trimmed by special devices adaptable to the particular type of commodity being handled. It is reported that comparatively little work is required to enable a change over from one type of cargo to another and only a small amount of cleaning is required for conveyor belts and parts of equipment which come into direct contact with the cargo.

COAL HAULING AT SYDNEY

The Maritime Services Board, in conjunction with the Department of Railways, has in hand the construction of a coal-loading plant at Balmain in Sydney to handle western coal. A jetty 100-ft. wide is under construction at present on which, in the first instance, a single travelling loading tower will be installed, provision being made for extending the jetty and the installation of a second loading tower.

Coal will be railed to Balmain in 40-ton trucks fitted with bottom-discharge and will be conveyed to storage bins, with probably 20,000 tons capacity, by conveyor. The coal will then be fed to the loading tower or towers by belt. It is hoped to provide for a loading rate of 500 tons per hour, but it will be little use providing for such a high loading rate unless ships that take the coal at that rate are available. The matter of fitting some form of trimming apparatus has not yet been considered, but I am of the opinion that without mechanical trimming it will not be possible to fully utilise the capacity proposed for the loader.

A system or method suitable to Port Kembla may be quite unsuitable for Sydney, so that each port must face up to its own problems and devise its own answers to those problems.

One urgent problem is common to all ports and that is the problem of reducing the " turn round " time of ships in our ports. If that can be accomplished by provision of bulk handling or other machines—observe that I use the word " if "—then those machines must be provided and provided quickly, for I am sure that in Australia we who are interested in shipping will find ourselves in grave difficulties unless the " turn round " of ships in our ports is materially reduced in the near future.

Diving Methods and Appliances

For Under-Water Work in Docks and Shallow Waters

(By a Special Correspondent)

WHEN reference is made to the unknown depths of the sea one is apt to think in terms of deep water, but after a few moments contemplation of the turbid waters of any of our major docks or rivers, it will be realised how little of what is taking place even just below the surface can be observed, and the unknown becomes less remote but no less mysterious.

Man's first efforts to probe these under-water mysteries began with mere endurance tests, relying on the capacity of the human lungs. Some negative buoyancy, such as a piece of lead or stone, was used to overcome the buoyancy of the lungs so as to enable the diver to get to the bottom. This method is still used by native divers in the warm waters of India and the West Indies in search of pearls and sponges, not without penalty when the short life span of these men is considered. It is surprising how long a man can remain under water; some demonstrators have frequently remained submerged for more than four minutes.

DIVING DRESS

The flexible suit and rigid helmet, which constitute the modern diving dress, was evolved very much in its present form by the middle of last century. The suit is made of a twill mixture of rubber and canvas, and encloses the diver from toe to neck in a flexible suit, and an elaborate corslet fitted over the shoulders enables a rigid helmet with a screw-on face piece to be secured to the dress, and to completely envelop the diver. An air supply pipe connects to the diver's helmet at one end, and to an air pump or air compressor at the other. As the diver descends through the water the pressure outside him increases about ½ lb. per sq. in. for every foot of depth. A valve in the diver's helmet enables him to adjust the air pressure inside his suit to that of the surrounding water. Under the influence of this equalising pressure inside, the diver's suit balloons out and his buoyancy becomes very great. His consequent tendency to surface is overcome by clothing the diver with heavy boots and heavy weights outside his suit; the total weight of the diver and his equipment in air being something like three times that of his ordinary weight.

Metal suits with flexible joints have been designed for special jobs, such as the salvage of the gold in the wreck of the " Egypt " sunk in 60 fathoms in the Bay of Biscay, but these have only been partially successful for doing actual work under water. They are useful, however, as observation chambers from which the diver can pass instructions by telephone to the salvage hands operating gear on the deck of the salvage vessel overhead. Practically the whole of the work of recovering over one million pounds in gold from the " Egypt " was accomplished by this method, and the diver seldom placed a hand on the wreck.

EFFECTS OF DIVING

The human mind and body normally thrives in an atmosphere of a pressure of 15 lbs. to the sq. in., and the ability of the complex human machine to withstand either less pressure, as, for instance, when flying high in an aeroplane, or more pressure, as when diving under water, is comparatively limited. Even in a flexible dress and rigid helmet, diving in depths greater than 300-ft. is not recommended, and at depths greater than 10 fathoms a diver is only permitted to remain working under water for a specified time, and his ascent must be made slowly with frequent halts, according to a carefully worked out Time Table.

Compressed air illness, to which a diver is prone, is caused by the absorption of nitrogen into the blood stream as the result of the exposure to high pressure air. In some cases the nitrogen is absorbed by the tissues, which become saturated and the complaint may then be serious.

When the diver is attacked by this illness it may be remedied quickly by restoring him to the depth at which he has been working, or alternatively, by sealing him in a recompression chamber in which these conditions are reproduced. The diver is then brought back to a normal pressure in slow stages. When diving in deep water the high pressure air causes a form of light-headedness, and it has been known for a diver to be given explicit instructions regarding the work to be performed at the bottom, but when he arrives at the job in deep water he has completely forgotten the purpose of his descent, and although he is connected with the surface by telephone it often proves impossible to convey to him what is required to be done, and he has to surface to obtain fresh instructions.

It is not intended to review deep diving methods in this article, because, firstly, it will seldom be necessary to employ this technique for under-water work in docks or in connection with port operation, and secondly, because the method requires highly trained divers and elaborate equipment. In the salvage of submarines and treasure sunk in deep water the problems are seldom alike, but they all require, for their solution, a complete understanding of the physiology of diving and deep diving methods, which are in the nature of a special study.

An interesting point in connection with deep diving is that the deeper a diver is, the less serious is a fall. Supposing a diver is working near the surface and owing to carelessness he falls 5 fathoms (30-ft.), he has an additional pressure of nearly 15 lbs. suddenly applied to every sq. in. of his body, and the volume of air in his dress is halved. His head and body will be thrust up into the rigid helmet, and he will probably be seriously injured. If, however, the diver is at 165-ft. and falls 5 fathoms (30-ft.), the pressure is only increased in the proportion of 7 to 6, so that the effect of the fall will be less.

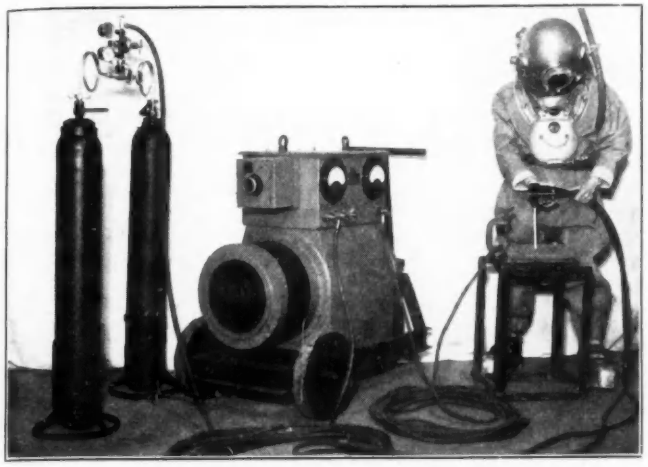
SHALLOW WATER DIVING

Advances have been made in the use of shallow water diving equipment for use in depths up to 40-ft. This equipment is most valuable when it is necessary for a diver to enter an enclosed compartment to which access in the inflated diving suit would be denied. There are several methods suitable for carrying out diving work in shallow water, of which the " gas mask " diving is, perhaps, the simplest to use. The " Salvus " apparatus and the " Davis Submarine Escape Apparatus," are in this class, and can be used for limited periods, either with the diver as a self-contained operator or in a shallow water diving dress with a surface air supply.

For the " gas mask " diving method an ordinary general service respirator is adapted by disconnecting the connecting tube at the face-piece end, the outlet valve of the face-piece is blanked off, and a 3-ft. length of flexible rubber pipe is connected by a watertight joint to a tube connection on the face-piece. The mask is now ready for use, and the free end of the flexible pipe is coupled to the air hose of a diving pump or an air compressor. The diver dresses himself in a boiler suit, or some other protective clothing, lashes the flexible air pipe to his waist, and slips on the face-piece in the ordinary way. At the same time the diving pump is started. He will need a handy-sized weight of from 4-10 lbs. which can be kept in the pocket of his suit; some divers find a steel bolt quite sufficient to give them the necessary negative buoyancy to descend. The diver is now ready to enter the water. When under water the air supply to the inside of the face-piece exhausts out of the side cheeks, and it is important not to stop the air pump for any length of time, as the diver may quickly become affected by carbon dioxide due to there being no fresh air supply round his head.

There are hazards, such as the face-piece being torn off, and the diver has no control over his air system, and cannot blow himself up in an emergency. The chances of these things happening are reduced to a minimum if diving is confined to shallow water. Probably the maximum benefit is derived from this method in

Diving Methods and Appliances—continued



[Photo Courtesy Siebe, Gorman & Co., Ltd.
Complete Oxy-Electric Underwater Cutting Outfit.

tropical water, where the water is warm enough to allow prolonged exposure under water, and when a diver in a full diving dress with rigid helmet would rapidly become distressed and overheated It is not uncommon for a diver under water in the Persian Gulf during a hot season to be forced to abandon his work after a very short time under water because of the intense heat inside the suit and the profuse perspiration. During the war, many tasks which could not be performed by a diver in a diving dress and helmet were successfully carried out using the " gas mask " method.

The work of salving sunken wrecks at Massawa and Akyab, in Burma, was greatly accelerated by this means. In Akyab the divers performed nine or ten hours work under water for several weeks, without ill-effects. Much of this time was employed in tunnelling through mud underneath the wreck, and it was anticipated that the diver's ears would become blocked up with mud. However, it was found that by using plugs of cotton wool and carrying out a routine syringing of the ears after each day's work, the ears could be protected. Perhaps the most spectacular feat performed in a gas mask, fitted as described, was that of the diver who descended to a depth of 120-ft., where he passed through a manhole door into a tank 20-ft. deep, and then, having had a Temple Cox air bolt gun passed down to him from the surface, he fired an air bolt through the outer bottom plating, connected a high pressure air hose to the air bolt, and then returned to the surface, all in the space of a few minutes. This gives an illustration of what can be accomplished by a determined and skilful man in such equipment.

The " Salvus " beathing apparatus enables a diver to operate as an independent unit below the surface of the water, free from the trammels of an air hose connection to the surface pump. The diver in such a case has an oxygen supply under his control, and his length of stay under water is governed by the capacity of the oxygen bottles and the speed at which it is consumed. This latter varies greatly with individual divers.

AIR COMPRESSORS AND TOOLS

A diver's ability to do useful work under water has been greatly increased by the introduction of the internal combustion engine and mechanically driven tools, particularly pneumatic tools. The air compressor, usually a diesel engine, besides supplying air to the diver also supplies the air to drive a variety of under-water tools. The modern air compressor is in itself a very reliable machine, but it is usual to safeguard the diver's air supply by having an air reservoir in reserve which can automatically take over the duties of supplying air to the diver if the compressor engine breaks down. A further safeguard may be provided, if it is considered necessary, by an ordinary hand pump or, if the depth warrants it, two such pumps joined in parallel. These pumps can be connected to the air supply panel, in readiness to be brought into use in the event of a breakdown. The ordinary hand pump, although somewhat laborious, is still retained for use on jobs in shallow water which do not justify the use of an air compressor.

A good deal depends, in under-water work, on the diver's ability to gain access to the job to be done. Once this difficulty has been overcome, such machines as the pneumatic drilling machine, fitted with a steel drill or wood auger, the pneumatic driven chisel, enabling cuts to be made through the high tensile steel, the air driven winch, and air driven wood saw, are all tools which can be successfully used under water.

A tool which has proved of great value in carrying out under-water work is the Temple Cox bolt firing gun. At one time if it was desired to fit a stud to the steel hull of a sunken wreck in order to screw a plate on, it was necessary, first of all, to drill a hole and then to tap and thread the hole by hand, which was often a long and tedious job. A diver equipped with a Temple Cox bolt firing gun is now able to shoot a stud into a steel plate. The stud pierces the plate and lodges in it, leaving a length of several inches of $\frac{5}{8}$-in. thread bolt projecting from the plate.

USE OF EXPLOSIVES

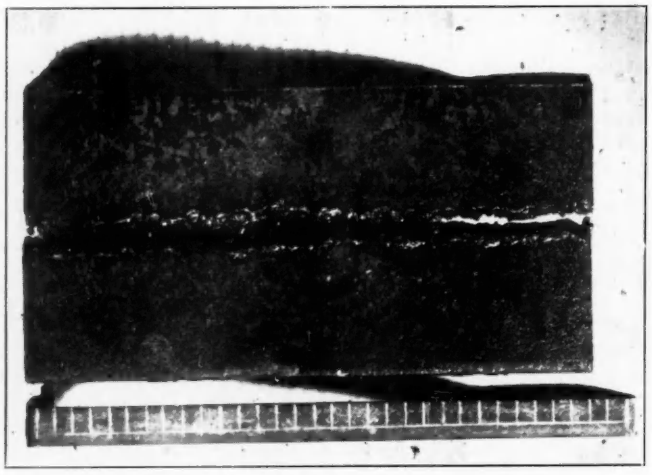
The ordinary $\frac{5}{8}$-in. bolt, as first described, has proved of great value for securing charges in carrying out demolition work under water. It is essential that the charge is secured close up against the work to be demolished. When using explosives on land it is often a comparatively simple matter to ensure that the charge is placed and is kept close up against the job, but when using explosives under water this requirement which is no less essential may present some difficulty. A charge placed under water has to be left whilst the diver ascends and gets clear, and in the interval between the diver leaving the work and the detonation the tidal movement may easily dislodge the charge, and even if a small water cushion forms between the charge and the job the effect of the explosion will be reduced. With the aid of a few judiciously placed Temple Cox bolts, a long sock of explosives may be secured in position to prevent this happening. The element of uncertainty which arises when a demolition charge misfires is magnified when the misfire takes place below the surface of the water, and it repays

Photograph showing Diver actually cutting mild steel plate under water using Oxy-Electric Arc Underwater Cutting Gear.

Diving Methods and Appliances—continued

the diving officer to be careful in the selection of the type of explosive, paying special regard to its age and proper priming, and the use of the right detonator. Cordtex fuse is a frequent source of misfire when used under water, and should not be used when other methods are available. Generally speaking, indiscriminate blasting is seldom profitable, and any preliminary care which will avoid a misfire or repetition of the work is well worth the trouble.

The effects of an explosion under water on a diver have given rise to all sorts of speculation, and there are cases on record where the effect of the detonation of a 300 lb. charge of amatol (a depth charge) has been felt by a diver working nearly two miles away from the explosion. Considerable experience in this field was gained during the recent war, and in those cases where the effect of an explosion has been felt at a remote point, the depth of both the diver and the explosion has probably been great. In those cases where the diver has been injured, it has been attributed to the diver being forced up into the rigid diving helmet of the ordinary diving suit.



Photograph showing cut made in ½-in. mild steel plate 30 cm. long. Time taken 1 minute, using Oxy-arc Electric Underwater Cutting Equipment.

It is now estimated that in shallow water say up to about 30-ft. a diver is reckoned to be safe, providing he is wearing a flexible suit and a kapok protective jacket, if he is 300-ft. or more away from the detonation of a 100 lb. charge. As the depth increases, the distance away from the charge must also be increased, and it is advisable that the officer in charge of diving operations should be kept well informed of any under-water explosions which are likely to take place within the area in which he is working.

UNDER-WATER CUTTING AND WELDING

For cutting iron or steel in air with the oxy-acetylene torch, the acetylene is the heating agent and the oxygen is the cutting agent.

The same principle may be applied under water by using the oxy-hydrogen torch or an oxy-arc electric cutting torch. As in most other work involving the use of tools, the diver who has achieved proficiency in the use of tools and cutting equipment on the surface will experience little beyond minor initial difficulties in operating an under-water current torch.

VISIBILITY AND PHOTOGRAPHY

Visibility under water is a problem which has, so far, defied proper solution, and it is naturally a limiting factor in the the amount of useful work which a diver can perform. In tidal waters enormous quantities of suspended silt are constantly on the move, blurring the diver's vision. This movement often rules out diving when the tide is flowing, and slack water periods must be seized as opportunities when visibility may improve by several feet. There are, perhaps, some circumstances when the diver's inability to see may be an advantage, on the principle that it is not always desirable to know the terrors which lie ahead.

There are no serious technical difficulties in the way of providing a powerful illuminant below water, but this is no more successful in penetrating silty gloom below water than a powerful illuminant is in penetrating fog on land. It will certainly assist the diver to identify objects which are close at hand, but where there is silt in suspension it is not of great value; its effect is rather to change the surrounding gloom and darkness to the appearance of a street lamp viewed through fog.

A camera in a watertight housing which is naturally buoyant, with its own power supply, carrying 200-ft. of film, has recently been tested for taking photographs under water. This equipment, like other types of equipment which have been developed for use under water, only operates under certain very special conditions, and these conditions are usually only found in places like the Mediterranean, where the visibility under water is good. It should not be supposed, therefore, that the camera will be of much use where these conditions are absent. Not every good diver is gifted with the ability to give a precise description of what he has seen under water, and if the water is reasonably translucent a camera will be able to photograph under-water damage to propellers outside without the necessity always of dry docking.

Dock Wages in U.K.

Statement on Agreed Increases

Negotiations for increased rates of pay which have been proceeding in this country for some months past, between port employers and dockworkers have resulted in agreement, and the following statement was issued early last month on behalf of the National Joint Council for the Port Transport Industry:

" Negotiations upon a claim for an increase in wages of dockworkers presented by the trade union side of the National Joint Council for the Port Transport Industry have now been concluded, and an agreement signed by the parties will come into effect as from Monday, February 12th. The agreement provides that

(1) time workers whose present daily wage is 19s shall have an increase of 2s. per day, bringing their minimum daily wage on a half-daily basis to 21s.;
(2) piece-workers are to have appropriate increases in their piecework rates;
(3) the weekly wages of permanent men are to be increased by 11s. per week.

In order to promote efficiency and smooth-working in the industry, the Council is restating in the agreement certain principles which govern the introduction of mechanisation, the determination of manning scales, the approach to restrictive practices, and unauthorised absenteeism."

The claim was submitted by four unions—the Transport and General Workers' Union, the National Amalgamated Stevedores and Dockers, the Municipal and General Workers' Union and the Scottish Transport and General Workers' Union and a point of special interest in the agreement now arrived at, is the attitude of the employers with regard to absenteeism, and improved methods of handling goods at ports by mechanisation.

The new offer was accepted by a delegate conference of the four unions by 46 votes to 23. In small ports outside the Dock Labour Scheme, the present differential of 1s. a day less than the principal ports will disappear, so that the minimum day wage will be 21s. throughout the country. Adjustments will also be negotiated in the pay of certain maintenance men employed by the Clyde Trust and the Manchester Ship Canal, whose wages move in conformity with dockers' rates.

SHOREHAM HARBOUR SCHEME TO PROCEED.

Shoreham Harbour Trustees have now been informed that the British Electricity Authority have decided to proceed with the improvement scheme for Shoreham Harbour in accordance with the provisions of the Shoreham Harbour Act, 1949, in order to provide for the berthing of larger colliers bringing coal to the Southwick Power Station.

Construction of Harlingen Breakwater

New and Economical Method Employed

By Ir. E. KUIPER, C.I.S.M.
Executive Engineer of the Holland Department of Hydraulic Works.

SYNOPSIS

THE construction of the harbour breakwater at Harlingen in the Netherlands represents a completely new departure from traditional methods. The site on the Wadden Sea is fairly sheltered, but it does receive heavy sea during North Westerly gales. The new harbour arm, 1,000 yards long is composed entirely of sand, protected from wave action by a bituminous cover. The thickness of the cover at the belt, subjected to severe wave attack, is 16-in., at other places the thickness is 10-in. The subaqueous revetment is over most of the length made of the usual willow mattresses covered with broken stone. Over a length of 100 yards prefabricated asphalt mattresses are laid, 6-in. thick. The asphalt mixture above high-water level contains 5% bitumen, between high-water and low-water 8% bitumen and 10% filler, the mattresses contain 20% bitumen. A surface dressing was given to the 5% and 8% mixture of bitumen and shell sand to give the surface more resistance against wave erosion. The cost of the work was about £200,000. There was a great saving in this design compared with the usual design of sand, covered with clay and stone pitching. Besides this, it was possible to build the dam in about half the time, the usual construction would have required. As far as the quality of the new material can be considered yet, it seems to be quite a success. It is in an excellent condition and reveals no sign of failure or deterioration. Nevertheless, it may take another ten or twenty years before the final appraisal can be made. The main aim of this paper is to reveal all the difficulties encountered during the construction and to account for the trend of thought which has led to the final result.

INTRODUCTION

In May, 1947, a proposal was made by the Chief Engineer of the Rijkswaterstaat, Ir. A. Burger, to cover a part of the new harbour arm at Harlingen (see Figs. 1 and 2) with a bituminous cover, instead of the usual clay and stone pitching. This type of construction would give the advantage of lower cost and a much faster execution.

The origin of this idea was a small-scale experiment to investigate the possiblility to substitute boulder-clay by mass-asphalt containing 5% bitumen.

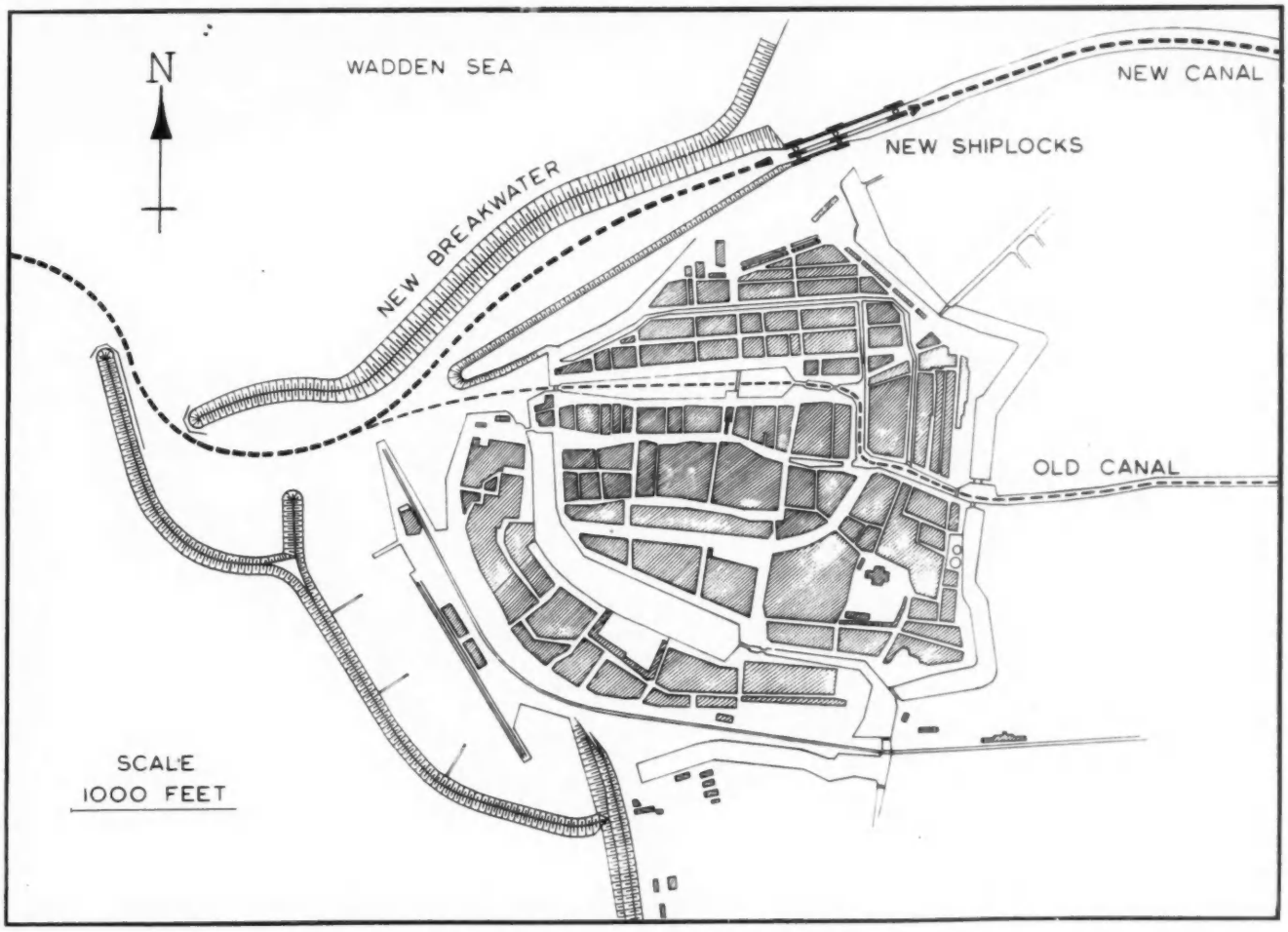


Fig. 1. Harlingen Harbour and connecting canals.

Construction of Harlingen Breakwater—continued

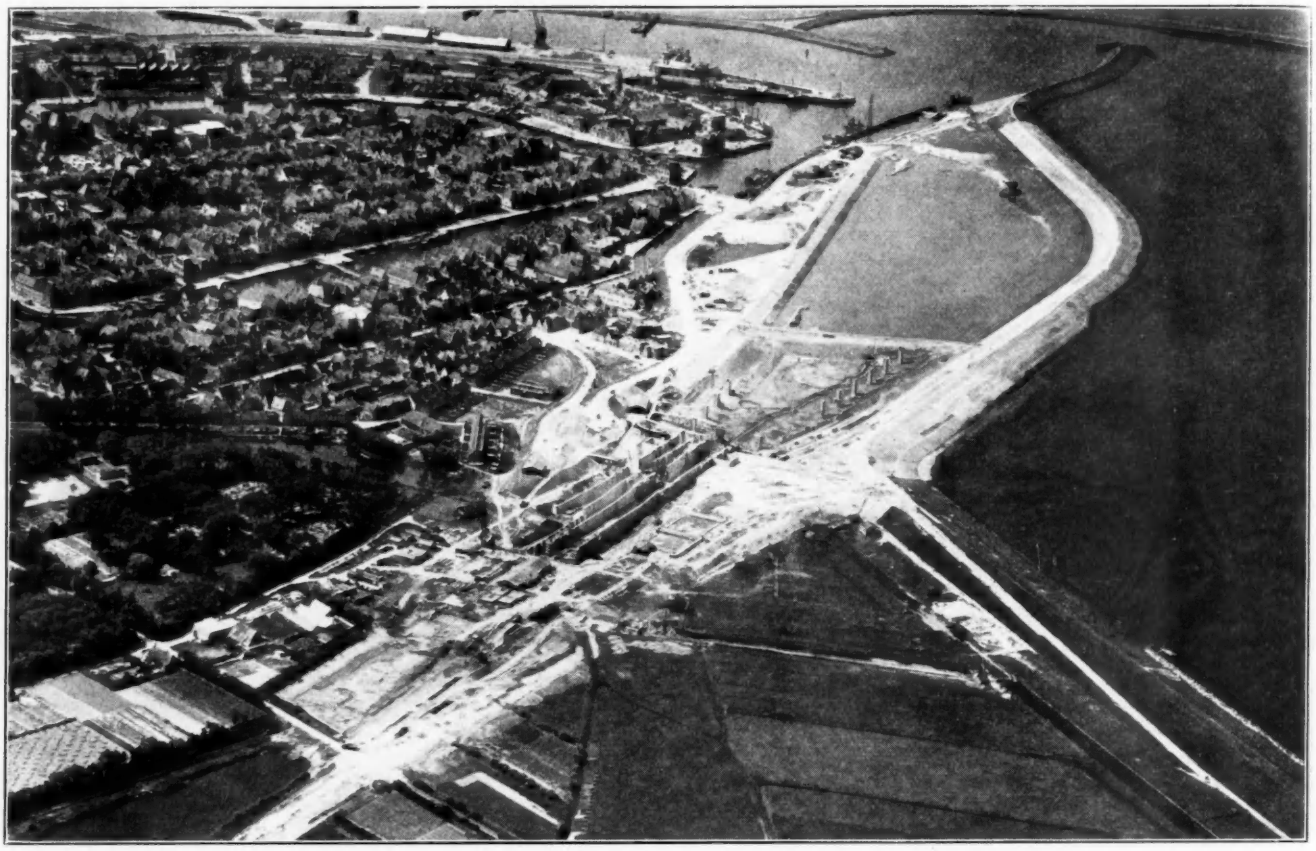


Fig. 2. Aerial view of Harlingen Works.

The hot mixture was dumped in fast flowing water and did not disintegrate. The material even retained a considerable solidity.

At the time it was practically unknown in Holland how to use asphalt mixture in dike building and subaqueous constructions. Some American reports were available which, however, were not a too sure guide, because circumstances were quite different.

METHOD OF CONSTRUCTION

At the beginning of the construction the following procedure was worked out: The muddy upper part of the sea bottom at the base of the dam would be dredged down to a level of 10-ft. below N.A.P. (mean sea level). At both sides of this " under water channel " ridges of mass-asphalt would be dumped, up to a level of mean low tide, which is about 3-ft. below N.A.P. Between these ridges, sand would be dumped by a suction-dredger (see Fig. 3), on which a layer of mass-asphalt could be placed between mean low tide and N.A.P. The higher part of the breakwater could then be built-up in the usual way and be covered by the projected layer of 25-in. bituminous cover. From a design point of view this gives a desirable cross-section. The toe of the dam is heavily built and will resist wave attack, whilst there is a good connection with the upper revetment. From a constructional point of view, however, there are some drawbacks. First of all it is not easy and rather expensive to place the heavy ridges of mass-asphalt on the bottom of the channel. Therefore it was decided to leave out the ridges and to dump the sand in the open sea. This may seem strange, but it should be considered that, from an economical point of view, a loss of approximately 200 cu. yards of sand would only cost the same as the construction of one yard of ridge.

The subaqueous revetment was planned to consist of a layer of 30-in. of mass-asphalt dumped on the slope under water (see Fig. 3).

This was how we started in 1947 with the first part of the 1,000 yards long breakwater. After some weeks it seemed not to be quite a success. By reason of tide currents and wave attack, too much sand was deposited beside the dam. It was found impossible to get the slope of 1 : 6 as shown in Fig. 4. Instead a " beach " was formed with a slope of 1 : 20.

To obtain temporary protection for the part of the dam above N.A.P., to be built shortly after this, it was necessary to cover this " beach " with a layer of 10-in. bituminous mixture (see Fig. 5), which made a special " toe construction."

During the construction of the breakwater above the level of low tide, the bituminous mixture turned out to be a valuable auxiliary material. The ridges, necessary to retain the flow of the sand in the right places, were built of sand and covered with a thin layer of this material (2-in. to 3-in.) between low and high tide which also gave a temporary protection against wave attack (see Fig. 6). In this way it was possible to eliminate the otherwise necessary ridges of boulder clay which would have been very expensive. Once the body of sand was above the level of high tide, the rest of the building up was easy and the final bituminous cover could be placed upon the slopes from the " beach " up to the top.

When the first part of the breakwater was finished, in the winter of 1947-1948, we got together to consider improvements for the construction of the rest of the dam. The method of construction between low and high water was very vulnerable as it had been carried out to that time. The construction of the toe should be improved. The loss of sand ought to be reduced. How could those improvements be attained?

After much consideration the following proccdure was adopted: The body of sand up to N.A.P. was deposited by dumping from self-discharging barges and by dumping from suction dredgers. At the moment the breakwater had reached a level of N.A.P. a drag-line was moved at low tide to the utmost point of the dumping-ground and was used to make the proper seaside slope. Directly after this, the mattresses of asphalt mixture and the timber sheeting

Construction of Harlingen Breakwater—continued

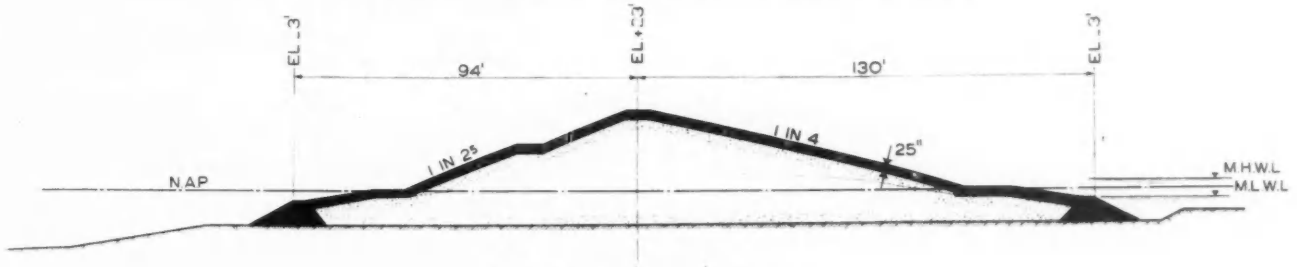


Fig. 3. First design of breakwater.

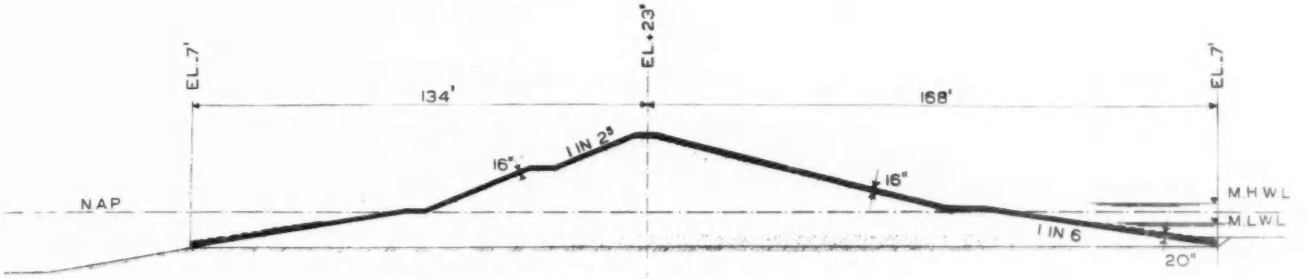


Fig. 4. First construction of breakwater.

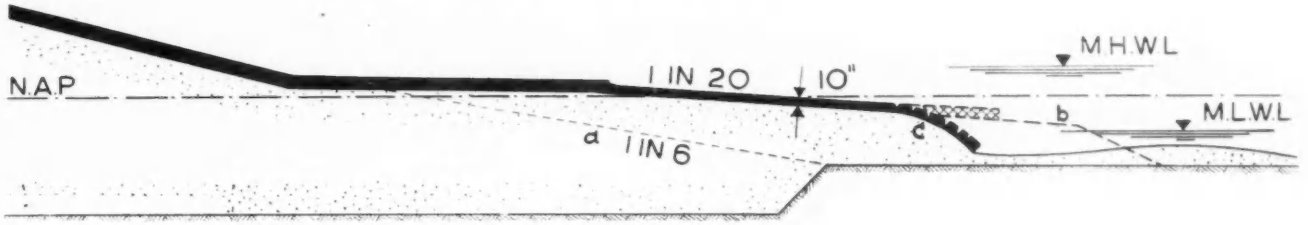


Fig. 5. Beach cover construction.
Dotted line a: The subaqueous slope as it was planned (see Fig. 3). Dotted line b: The subaqueous slope as it turned out. At point c: The sand was removed under the revetment by wave action. The bituminous cover went down, bended and cracked but protected the toe of the dam from further damage.

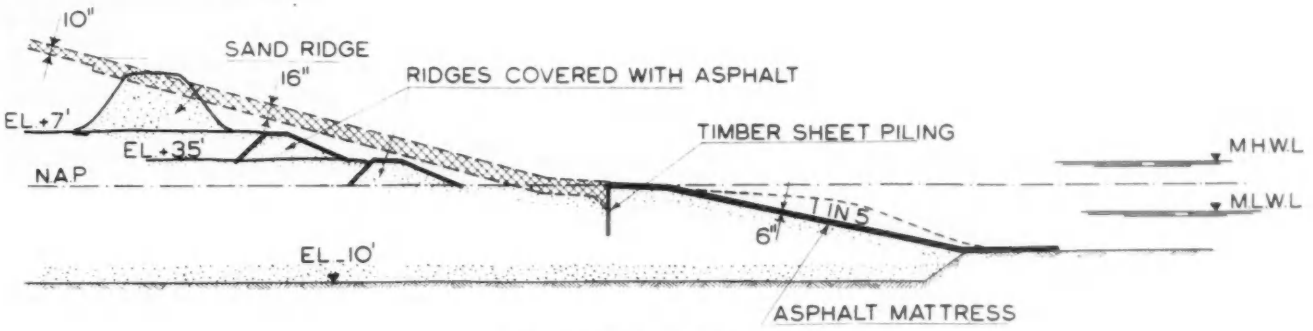


Fig. 6. Method of Construction:
1. Removal of mud down to — 10-ft.; 2. Pumping of sand up to N.A.P.; 3. Grading of subaqueous slope; 4. Driving of sheet piling; 5. Placing of asphalt mattresses; 6. Construction of first ridge; 7. Core of the dam pumped up to + 3.5-ft.; 8. Construction of second ridge; 9. Core of the dam pumped up to + 7.0-ft.; 10. Construction of bituminous cover up to + 6.0-ft.; 11. Construction of sand ridge; 12. Core of the dam pumped up, etc.

were placed and the first auxiliary ridge was made (see Fig. 6). This all had to be done at one low tide, during which the pumping of sand had to be stopped of course. It was quite a problem to achieve this in the time available, in particular when the wind blew strongly west, cutting down the period of the low tide. Nevertheless it can safely be stated that all the difficulties which we experienced were worth while as compared with the use of the much more expensive auxiliary material of boulder clay.

THE REVETMENT ABOVE N.A.P.

It has been pointed out already that at the beginning of the construction nothing was known about the required thickness and composition of the covering of the breakwater. The thickness of the revetment would depend on the firmness of the material, which was unknown. At the outset we planned a thickness of 30-in. After having finished the first part of the breakwater, this was reduced to 16-in. up to the level of the storm tide and 10-in. above this level (see Fig. 7).

As far as the composition of the material is concerned, it was supposed that at least all grains of sand had to be coated with a thin layer of bitumen. Using the sand of Harlingen (see Fig. 8) it was estimated that 5% (by weight) would be sufficient. Rather soon we discovered a considerable difference in firmness of the covering between N.A.P. to M.H.W.L. and the part above that

Construction of Harlingen Breakwater—continued

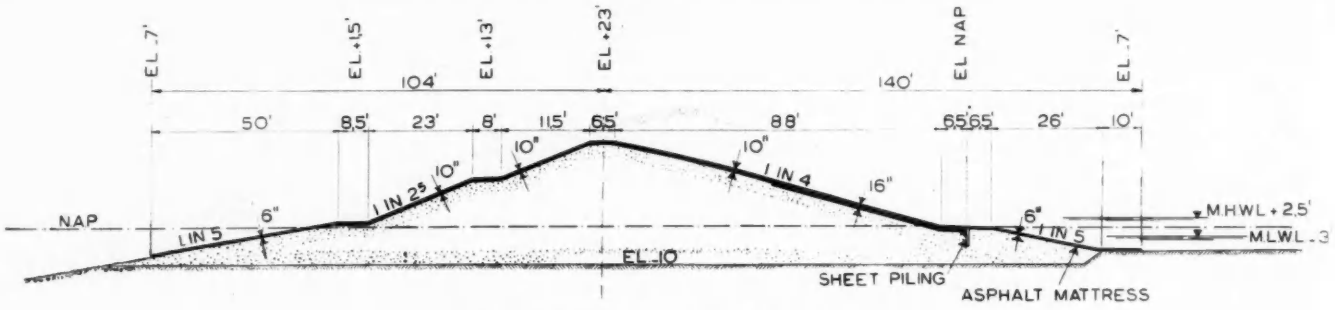


Fig. 7. Final cross-section of breakwater.

level. It was evident that in the lower part the water which came on the fresh material some hours after it was placed in position had a very bad influence. To discover the cause of this, we changed the temperature of the material, the percentage of bitumen, the quality of bitumen, etc. without any satisfactory result. Finally we discovered that a slight addition of filler considerably improved the firmness. A proportion of 8% bitumen and 10% filler gave excellent results, just as good as the 5% bitumen above H.W. level. What was the physical background of this? The following opinion about this phenomenon may be stated :

When solid matter and liquid come in contact with each other there will be a certain affinity according to the surface tension of the liquid against the solid matter. The properties of sand, bitumen and water are such, that the affinity between water and sand is greater than between bitumen and sand. As long as the bitumen is still in the liquid phase (high temperature) there will be opportunity for the water to remove the bitumen from the grains of sand, which will of course decrease the firmness of the bituminous mixture. This process of stripping can be reduced by two means. Firstly to lower the temperature of the material when it is placed on the slope: this, however, cannot be done very effectively, because it is from a constructional point of view undesirable to go lower than 150° C., at which the bitumen is still liquid. Secondly by increasing the viscosity of the bitumen, because that will decrease the progress of the process. It turned out that this could effectively be obtained by adding weak hydraulic filler to the bitumen. The mixture of bitumen and filler has such a resistance against the stripping force of water that the firmness of the material is practically completely retained. The mixture consisted now of : 82% sand, 8% bitumen, 10% filler. Until now, the quality of the revetment has been discussed on the level of " firmness " which is, of course, rather unscientific!

It is, however, very difficult to express the quality of this kind of revetment in figures. We made, for instance, beams of the 5% material of 8-ft. x 16-in. x 16-in. Supported at the ends, a beam could be loaded in the middle with 6,000 lbs. before it cracked! When, on the other hand, they were supported at both ends and left to their own weight, they cracked also, but after 24 hours. This gives an indication what an important role the factor time has on the behaviour of this material. It is possible to measure in a laboratory a pressure of force at a given cube, at a given temperature, at a given rate of impression. These figures, however, have little value for practical purposes because actual pressure will act much quicker (the shock of a ship) or much slower (the weight of the material itself) than it was done in the laboratory. Probably the best thing to do is comparison of different mixtures by shock-test at given temperatures. An iron ball of given weight is dropped on a tile of asphalt of given dimensions. The height of fall is now determined, at which the tile cracks.

At the start of the construction it was tried to consolidate the whole layer of bituminous mixture. Light and heavy rollers were used at high and low temperatures, mechanical pounders, tractors and other equipment. In each case we experienced that the material was displaced and moulded instead of consolidated, because the thickness of the layer was too great (16-in.). We did not want to build up the revetment out of thinner layers because these layers will not stick to each other and therefore the resistance of the whole construction would decrease. On the other hand, one may ask if it is necessary to consolidate the bituminous cover of hydraulic works. The only advantage will be a slight increase in resistance against shocks. The resistance against the influence of water and air will be the same. The permeability will decrease which can mean a disadvantage when the circumstances are such that a water pressure can build up under the revetment! These reflections have led to the decision to drop the requirement of thorough consolidation. To give the surface of the layer more resistance against the erosion of the waves and wind and against the heat of the sun, it has been coated with a thin layer of pure bitumen and shells

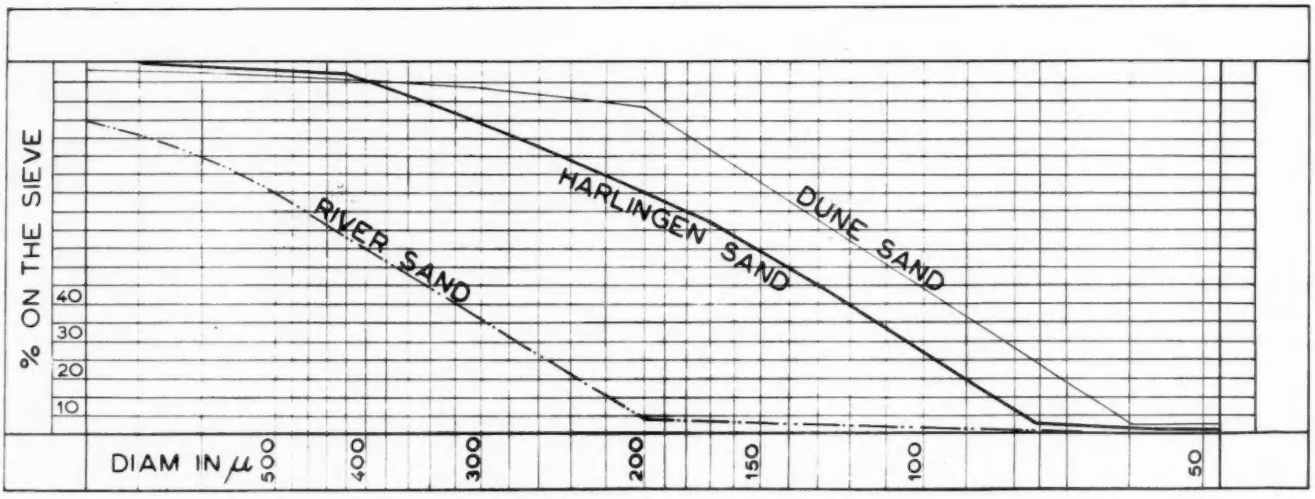


Fig. 8. Grain-size curve of Harlingen sand, used for core of the dam and bituminous mixture.

Construction of Harlingen Breakwater—continued

(see Figs. 8 and 9). The bitumen and the shells were attached when the mass-asphalt was still hot, to insure the contact between these materials. This result was very satisfactory.

THE REVETMENT UNDER N.A.P.

The construction of a good subaqueous revetment turned out to be the most difficult problem. We started with dumping large quantities of a 5% mixture under water. This was very costly, the slope was not covered entirely and dumped units did not stick to each other very well. The next attempt was the dumping of a rich mixture in quantities of about one cubic yard. This was even costlier and the slope was still not covered entirely. This led us to the idea of guiding the fluid asphalt mixture by an insulated steel tube to its position on the slope, both to keep it hot as long as possible and to get it in the proper place. It turned out that the tube plugged up and that it was almost impossible to check what was done under water. At last we decided to use prefabricated asphalt matiresses which were made on a quay of the old harbour, transported by barge to the dam and laid by crane on the slope of the dam (see Fig. 10). The first problem that arose was to choose the best percentage of bitumen and the type of reinforcement. The mats should be of flexible during transport, without cracking; they should have proper weight for their final purpose of protection and they should be cheap as they had to compete with willow mattresses covered with stone.

In December, 1947, after carrying out some other attempts on a small scale, we made, transported by crane and laid, an experimental mattress 15-ft. wide, 30-ft. long, 6-in. thick, containing 20% bitumen and reinforced by two steel cables. This experiment was quite a success. Bending was possible without cracking, heavy waves did not move the slab and the price was fairly low. When tenders were called for the next part of the dam, it was specified in the contract that asphalt mattresses 15-ft. x 45-ft. x 6-in. thick with 20% of bitumen had to be laid. The contractor was free to choose his own way of transportation. He choose, however, the crane method, started in the summer of 1948 and had the one failure after the other! In the first series the steel wires were too weak (Army dump wires, guaranteed for 10 tons, broke at 3 tons!). In the second series during the pouring of the weak asphalt mixture the wires sagged to the bottom of the forms and could later on not get a good hold on the material, when lifted by the crane. The wires stripped out of the slabs which fell apart. In the third series the wires were not stretched enough during the pouring and the stiffening of the asphalt mixture. Hence the force in the wires when hanging in the crane was not distributed equally in the slab. The result was cracking in the upper part of the mattress and later on falling apart of the rest. In the fourth series all the necessary precautions were taken and no more failures occurred. One experimental slab remained for one full hour in the crane and nothing happened. The mattresses then were of the same construction as was described in the contract. They had four steel wires in the length of the slab with small steel plates of 2-in. x 2-in. attached normal to the wires at every yard. The wires were stretched carefully before the pouring of the asphalt mixture. No more reinforcement was applied in the slabs. One may ask now why the experiment in 1947 was such a success and why in 1948 the contractor encountered so many difficulties. This was due to the difference in temperature. At low temperature mass-asphalt can be allowed a much greater tension than at a high temperature. Therefore it turned out in the summer of 1948 that more precautions had to be taken than in the winter of 1947 had been done!

Another solution of the subaqueous revetment was a so-called "beach cover." It was derived from a mistake at the first part of the breakwater (see Fig. 5). Instead of making the slope under water 1 : 6, so much sand was deposited beside the dam up to a level of about N.A.P. that at low tide a beach existed of about 50-ft. wide. On this beach mass-asphalt with 20% was poured in a layer of 45-ft. wide and 6-in. thick for a length of 200-ft.

Wave action and sea currents effected the removal of the sand under the front side of this giant slab, by which it slowly went down until it reached the bottom of the sea. During this movement constant tension appeared in the material. Accordingly it was considered necessary to reinforce the slab. This was done by a netting of sisal rope, ¼-in. diam., with the ropes 2-in. apart. For a certain stretch no netting was applied and this turned out to be the place where the slab subsequently cracked (though it did not fall apart). The application of steel netting was unsuccessful because it wrinkled out of the slab during the pouring of the mass-asphalt by reason of the heating and undesirable because it did not have a definite bond with the material by reason of its thinness.

Fig. 9. Laying bituminous mixture.

Fig. 10. Seal coat of pure bitumen and shells.

Fig. 11. Laying asphalt mattresses.

(See also Correspondence on Page 347)

IMPROVEMENTS AT THE PORT OF BANGKOK.

A development contract for Bangkok Harbour, costing $4,400,000 has been awarded to the Amsterdam Ballast Company. The cost of the work will be met by a loan from the World Bank to the Thailand Government and the scheme provides for the deepening of the channel in the Chao Phya Menam River which connects Bangkok with the Gulf of Siam. At present, only vessels of about 6,000 tons can reach Bangkok, but when the channel has been deepened, large ships will be able to unload and load in the Bangkok Harbour, thus avoiding transhipment by barges. Most of the labour for the work will be obtained from Thailand but the supervision will be undertaken by Dutch Engineers, and the equipment also will be largely Dutch. A good deal of the Company's machinery now being used to make the parallel channel for the Suez Canal will be shipped to Thailand. The project is expected to be completed within 18 months, but no further details of the scheme are yet available. It is hoped that when the project is completed it will considerably reduce the cost of exporting rice from Thailand.

Education Scheme for Port Workers

Outline of Proposals made at Recent Conference

The following scheme has been advocated as the result of a conference which had its origin in a suggestion that there is a need for some fairly elementary courses designed to help port workers to a fuller understanding of the port industry. After consulting the Institute of Transport, the Association of Technical Institutions, and the Dock and Harbour Authorities' Association, those who made the suggestion invited the Chairman of the Docks and Inland Waterways Executive to convene a conference to discuss their ideas. Meetings were duly held, at which the following were represented:—

Dock and Harbour Authorities' Association
Docks and Inland Waterways Executive
Institute of Transport
Ministry of Education
National Dock Labour Board
National Joint Council for the Port Transport Industry
Railway Executive
Association of Principals of Technical Institutions
Association of Technical Institutions
City of London College.

The conference recognised that a number of port undertakings and port employers already have arrangements for training staff and giving them "background" knowledge and that the examinations of the Institute of Transport for its membership grades of Graduate and Associate Member (A.M.Inst.T.) are open to port workers who have a good general education, and that there are wide facilities for education in general mercantile subjects at the technical and commercial colleges throughout the country.

It is thought, however, that there is a need for elementary courses of study directly connected with port work which will meet the educational requirements of employees who do not take advantage of existing arrangements or who hesitate to attempt more advanced courses in transport. Such elementary courses should carry a nationally recognised certificate granted upon success in an examination for those who desire to submit themselves to examination. While it is the process of study which would be important, many students would undoubtedly wish to enter for examinations to obtain evidence of their attainments.

AIM AND APPLICATION OF SCHEME

The aim of the courses and the examinations is "To promote the study of the main essentials of ports and port working, their problems and background."

Whilst courses of study must conform with these general principles, it is recognised that differences in the organisation, terminology, and conduct of port working in different areas must be taken into account. It is therefore expected that educational institutions in each area, in consultation and in agreement with the local port interests as represented by employers and employees, will exercise a certain amount of latitude in adjusting the standard syllabuses in these respects.

In order to secure reasonably uniform standards throughout the country, the syllabuses thus drawn up must be submitted for approval to a central body, and any examinations based upon them, while set and marked by examiners with knowledge of conditions in the area, must be subject to moderation and assessment centrally.

The number of subjects will be three, to be taken together, or singly in any order. These subjects are the elementary study of: (a) Port Traffic; (b) Port Working; and (c) Port Organisation and Finance.

OPERATION OF SCHEME

(a) The Institute of Transport has been invited and has agreed to co-operate in the operation of the scheme so far as maintenance of standards, assessment and the award of certificates are concerned.

(b) It will convene annually a conference of representatives of the authorities sponsoring this scheme. That conference will elect the central body, whose duty it will be to examine syllabuses and modify or approve them. To initiate the scheme, a central body has been set up to operate for one year. Thereafter, as already set out, the annual conference, with representatives from any other organisations it may appear appropriate to invite, will elect the central body. The conference itself, being representative of the industry, will ensure that the future development of the scheme meets the requirements of those engaged in the industry.

(c) Syllabuses prepared by educational institutions in consultation with the port interests of the areas must be submitted to the Institute of Transport by the colleges which propose to conduct the classes, and must be accompanied by the names and qualifications of the proposed lecturers and examiners. Schemes must be submitted not later than the first week-day in June for courses proposed for the academic session beginning in any year in the following September.

(d) Where examinations are set, the proposed question papers must be submitted in duplicate to the Institute of Transport not later than two months before the date of the examination.

(e) A separate certificate for each subject, signed on behalf of the College and the Institute of Transport, will be issued by the Institute of Transport to each candidate adjudged by its assessors as successful in the examination. A Group Certificate will be granted if the three subjects are taken and passed at one session, and certificates in separate subjects in different years will be exchangeable for a Group Certificate.

PROVISION OF CLASSES AND TEACHERS

It is hoped that managements and trades Unions will give every encouragement to staffs to pursue these courses of study. It is felt that the courses recommended, being closely linked with practical experience, will appeal to many men who would not pursue more academic studies, and that those who take the courses will have a greater understanding of their responsibilities and of the problems of the industry.

It may be assumed that classes for the courses outlined herein will gladly be provided by the technical and commercial colleges of the local education authorities where there are sufficient students. But these colleges, if the students are forthcoming, will need teachers. For a few years the provision of good teachers may be a difficulty. The colleges must rely upon the fullest and most sympathetic co-operation from the industry in dealing with this problem. There are practical men in the ports who have passed the Associate Membership examination of the Institute of Transport in port subjects. Such men are likely to be well qualified to give the instruction, and it is hoped that employers will urge such members of their staffs to undertake the duty. They will need formal approval by the local education authority, who will pay them as part-time lecturers.

The basic syllabuses of the three subjects are as follows:—

PORT TRAFFIC

Geographical and economic factors which determine port location. Different types of port. History of growth and development of ports. Special facilities for shipping, discharging and warehousing main commodities handled at U.K. ports. Bonded warehouses. Rights and duties of port undertakings in relation to the requirements of H.M. Customs and Excise. Outline of import and export procedure including documents used.

PORT WORKING

Loading, discharging and berthing of vessels. Warehousing. Part played by ports in transhipment and entrepot trade and in marketing. Lay-out of port in facilitating terminal operation; road, rail and inland waterway conections with port. Equipment and appliances; lighterage facilities. History of dock labour from the beginning of Trade Union organisation in 1887; port labour and methods of payment; constitution and functions of the Dock Labour Board. Passenger traffic working. Industrial relations.

PORT ORGANISATION AND FINANCE

Constitution of authority. Organisation and functions of staff. Provisions of Transport Act 1947 in relation to Port Undertakings. Chief sources of revenue; main trends of expenditure. Procedure in collection of revenue and payment of expenses.

Correspondence

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

CONSTRUCTION OF HARLINGEN BREAKWATER

Mr. Kuiper has asked me to look through his article on the original and interesting work at Harlingen. E. J. R. Kennerell and I included a brief description of this work in our paper published in the Journal of the Institution of Civil Engineers, February, 1950, and dealt with some observations of Messrs. Burger and Kuiper in the correspondence published supplementary to the October Journal. This present paper gives a much fuller account by the man in charge and is correspondingly much more valuable. One cannot but admire the courage and steadfast resolve to succeed that is apparent in the enterprise.

When it comes to underlying theory there are grounds for argument and neither Mr. Kennerell nor myself can accept Mr. Kuiper's exposition. If sand and bitumen are heated sufficiently then a very small percentage of bitumen can be made to coat each grain of sand. In practice it will usually be found that 6½% bitumen is required for sea sand. At Harlingen the 5% bitumenised sand which was found to be unsatisfactory under water, in my opinion almost certainly suffered from lack of complete coating and it is unnecessary to seek more elaborate explanation. That the addition of filler to a bituminous mixture alters its properties has been known over a long period. It would appear that the filler material (passing 200 mesh) alters basically the binding properties of the bitumen. The shock test referred to is usually known as the shatter test when applied to pure bitumen, its application to asphalt (which in England means a mixture of bitumen aggregate and usually filler) is an unexplored subject, but it is difficult to envisage any definite conclusions. In other words, I find myself at once unable to accept Mr. Kuiper's theory, at the same time unable to put forward any generally accepted alternative.

177, Victoria Street, Yours faithfully,
London, S.W.1. C. H. DOBBIE,
30th January, 1951. B.Sc., M.I.C.E.

To the Editor of *The Dock and Harbour Authority.*

Sir,

CO-ORDINATION IN CARGO HANDLING

The subject of cargo handling and quay layout has been prominently featured in your Journal during the last year or two, and there is no doubt that your contributors are working along the right lines, as, of late, frequent reference has been made in the Press to the general increase in the sea speed of ships, and to delays in port.

Your readers will no doubt remember that two years ago Mr. MacGillivray presented a classic paper to the Institution of Naval Architects dealing with the inter-relationship of sea speed and port speed, and that parts of it, relevant to port organisation and equipment, were reprinted in the May 1948 issue of your Journal. In this paper he detailed some of the amazing devices which have recently been produced for the rapid mechanical handling of cargo. It is indeed no exaggeration to state that many ship types can be built to-day which are automatic in the discharge of their loads and sufficiently rapid in doing so to enable them to co-ordinate their sea and port speeds. Equally, shore equipment, and particularly pallettisation and the use of forked trucks, is so efficient that much labour can be dispensed with; a high rate of loading and discharge achieved with certain kinds of cargo.

Most of the developments of this kind however are localised, and there is neither standardisation of design nor co-ordination of knowledge and experience. Both of these are essential, if the naval architect, by what he puts into the design of his ships, is to increase port speed. It is useless to have, for example, in Port A, a device which can remove cargo quickly from certain ships, but which cannot handle others with equal celerity because hatches or side doors are inconveniently placed.

It has, therefore, been suggested that an International Committee, known possibly as the International Cargo Handling Co-ordination Committee, might be established. This will be purely unofficial, though of prime importance in the first instance to manufacturers of rapid cargo handling gear. The basic idea has been promulgated in France and there is considerable interest in it in Holland.

I have been asked to initiate steps which might make possible the eventual formation of such an international organisation, which would be truly international and completely non-government. I am informed that certain of the technical institutions would at least like, however, to hold a watching brief. It would be interesting to have the ideas of your readers as to the establishment of such an organisation, which would make possible the free interchange of all information about the newest devices for handling cargo rapidly, both those attached to shipboard and those on shore.

110, Fenchurch Street, Your faithfully,
London, E.C.3. A. C. HARDY.
February 1st, 1951.

To the Editor of *The Dock and Harbour Authority.*

Sir,

TOWAGE METHODS ON INLAND WATERWAYS

I was gratified by Mr. Lyon's interest in my article published in your December issue dealing with proposed improvements in handling craft on our inland waterways.

Following the public demonstration of the prototype "Bantam" unit in October 1948, we have since found these units can now operate with considerable advantage throughout the whole of the network of our inland waterways, by working a shuttle system between locks. I have excluded the tidal waters because the system of towing a train of barges under those circumstances is correct, but I have often asked myself how we came upon the idea of towing a string of barges on a canalised waterway. Is it not simply because that method was copied from the tideway, regardless of the fact that the circumstances were totally different?

Perhaps the best way to illustrate the saving effected by the shuttle system, is to imagine a stretch of canal 10 miles long from tidal waters to a discharging point requiring 6 barges per day. This 10 mile stretch is intersected by 3 locks and represents a day's work for a 100 h.p. tug towing 6 barges one way only. In other words this tug only makes 60 barge-miles, and another train would be required to bring the empty craft down. But by working a shuttle service with four "Bantam" pushing tugs of only 21 h.p. each, 120 barge-miles can be covered by a total of 84 h.p. in the same number of hours. In other words the empty craft are brought down too with less than half the tug-power. In addition, this method enables the same tonnage to be carried by 11 barges instead of the 18 required by the first method, and only 4 barges are on the move at any one time compared with 12.

There are other advantages which I cannot go into here for lack of space, but if any reader cares to hear more about this, or fails to see how the saving is achieved, I shall be only too glad to explain.

In conclusion may I commend Mr. Marsh on his excellent paper which he presented to the International Navigation Congress in 1949, and which was reprinted in last month's edition of "The Dock and Harbour Authority." His opening paragraph in which he referred to "The inherent characteristics of the English canal system may, however, be very helpful in the consideration of the problems involved." struck me as being particularly apt. There is a wealth of knowledge in the industry which, if pooled, could undoubtedly lead to the solving of the problems relating to the acceleration of craft.

Brentside Wharf, Yours faithfully,
Brentford, Middlesex. E. GEO. JONES.
17th February, 1951.

TENDERS INVITED FOR NEW WHARF AT PORT DARWIN

The Commonwealth Government of Australia is calling for tenders for the construction of a new wharf at Darwin, in the Northern Territory. The Government will supply the steel piles, beams and timber decking and the contract will be for construction only. The total deck area of wharf will be 80,000 square feet, and a set of plans, which may be seen by those interested in tendering, will be available shortly at Australia House, London, W.C.2. Enquiries should be addressed to Mr. M. B. B. Keatinge.

Correspondence—continued

To the Editor of *The Dock and Harbour Authority.*

Dear Sir,

"TIDAL SAND RIPPLES"

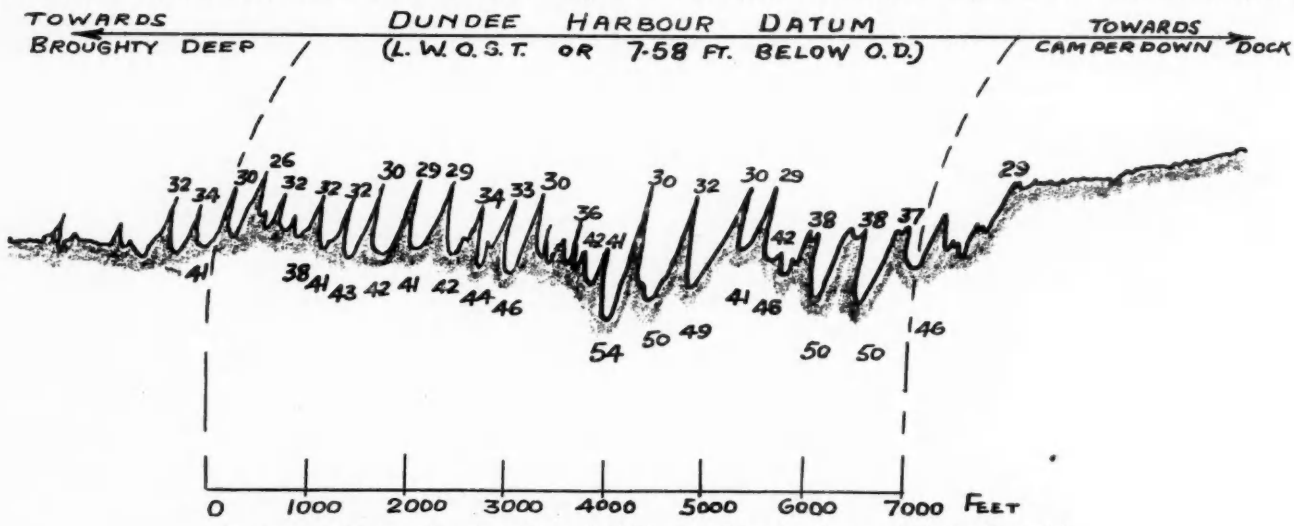
Sixty years ago, Osborne Reynolds drew attention to the sand ripples which he had observed on the bed of his tidal models. In his Reports to the British Association Committee appointed to investigate the Action of Waves and Currents on the Beds and Foreshores of Estuaries (1889-90-91), he points out (1889) that " if the models are similar to the results obtained in estuaries, the converse should hold, and the estuaries should be similar to the models. In which case we are face to face with a very striking conclusion, that in the estuaries there should be—call it ripple mark or wave mark, produced by the action of the tide, similar to that on the models and on a scale proportional to the height of tide in the estuary. Thus some of the ripples in the models are from hollow to crest as much as one-fourth the mean rise of the tide, the distance between them being twelve times their height. This, in an estuary, would mean 7-ft. or 8-ft. high and 80-ft. to 100-ft. in distance " . . . (1891) " The large tidal sand ripples below low water in the model estuaries, with the flood and ebb taking the same course, constitute a feature which it is impossible to overlook, yet the existence of corresponding ripples had been entirely overlooked in actual estuaries, until, when they were looked for, they were found to exist, having first been seen in the models. The reason that they were overlooked before is, no doubt, explained by the fact that the bottom is not visible below low water in actual estuaries; but this is not all. In the estuaries, these ripples, where found, have been confined to the bottom and sides of the narrow channels between high sand-banks, and they do not occur on the level banks below low water towards the mouths of estuaries to anything like the same extent as in the models." (This refers to models of hypothetical, " geometrically and symmetrically " shaped estuaries) . . . " in the models with boldly irregular boundaries the tidal ripples are much less frequent than in the symmetrical models, being confined to places where there are no cross-currents, as in actual estuaries."

Unfortunately, Reynolds does not seem to have placed on record any details of the places in Nature where such ripples had been found, nor any quantitative data as to their size, although one infers that it was of the order of those predicted by his models.

Thomas and Watt (" The Improvement of Rivers," 1913, vol. 1, p. 22) state that sand waves have been measured in the Mississippi with a height of 20-ft., moving at 80-ft. per day, and Dr. Vaugham Cornish (Geogr. Journal, vol. 18 (1901), pp. 170-201; Brit. Assoc. Rept. 1900, p. 733; " Ocean Waves and Kindred Geophysical Phenomena," 1934) has described many instances of ripples on sand-banks exposed at low water. These were of the order of 24-in. in height and 40-ft. in wave-length. I have myself seen similar formations—like saw teeth—on the Whiting Shoal in the Wash (East Anglia) and have suggested, with the supporting evidence of aerial photographs of the Cheshire Dee, that even a system of complete sand-banks may be an extreme case of ridge or ripple formation. Some of the major ripples on the banks which are exposed at low tide in the Dee are several feet high from trough to crest and ¼-mile or more apart.

The growing use of echo-sounding offers a prospect of gathering more information about this interesting phenomenon and probably many of your readers could supply instances from their own knowledge.

By courtesy of Mr. Alexander Smith, A.M.I.C.E., Engineer of the Dundee Harbour Trust, I am able to give details of certain large underwater sand ripples discovered in the estuary of the Tay. The accompanying diagram reproduces part of a longitudinal section of the channel between Camperdown Dock Entrance, Dundee, and the Lady Shoal. Over a distance of 8,000-ft. having its upper end 6,500-ft. east of the Dock Entrance, not fewer than 27 major sand ripples are clearly distinguishable. Their average pitch or distance from crest to crest, is some 300-ft., the longest being 500-ft. Their average height, from trough to crest, is 9-ft. and the biggest is 24-ft.



Longitudinal Section of part of Channel of Tay, by Echo Sounding on 30th October 1946.

The material in this region of the channel is a sand having a mean diameter, as seen under a microscope, of approximately 0.015-in. The average depth of water in this channel at low water of ordinary spring tides (range 15-ft.) is about 40-ft., and the surface velocities reach values of about 3¾ knots on the flood and 3 knots on the ebb (at spring tides).

The ordinary hydrographic charts give no definite indication of the existence of these sand ripples: the charts are either lacking in detail or the ripples have moved during the course of the ordinary sounding process.

Department of Engineering,
Aberdeen University,
26th January, 1951.

Yours sincerely,
J. ALLEN.

THE ARCHITECTURE OF TRANSPORT.

An exhibition with the above title is being held at the Royal Institute of British Architects, 66, Portland Place, London, W.1 from February 22nd — March 22nd (Weekdays 10-7, Saturdays 10-5). The Exhibition is divided into four main Sections—Road, Rail, Water and Air, and shows by means of photographs, plans and models, the architect's work in these fields. A large proportion is devoted to projects in the United Kingdom, but there is also an interesting selection of material from abroad.

Scales for Moving-Bed River Models

By T. BLENCH, B.Sc., M.I.C.E., M.A.S.C.E., Consulting Engineer

1. Introduction

This article was written, originally, on request, to answer the many queries and doubts of the non-specialised technical public interested in a certain large tidal model. The main cause for mystification was the adoption of a greater scale for vertical than horizontal dimensions, so that the model is relatively more than 8 times as deep, in terms of width, than the river — hereafter called the "prototype." Typical questions are:

1. How can a model with exaggerated vertical scale be expected to forecast the behaviour of the prototype?
2. Why are the scales distorted?
3. Is geometric similarity with the prototype necessary for dynamical similarity; if so, how can the dynamically dissimilar model forecast anything
4. Why is the model sand taken from the river instead of being scaled down?
5. How much time is used on the model to represent a day on the prototype? How is it decided?
6. Will the tides run up the river at the "right" speed?
7. How does one know how much water to run up to represent a given freshet?
8. Does the model follow the Froude criterion or the Reynolds one; if not, then what does it follow, and can it give useful answers?

The answers to these queries are interconnected and require some technicalities. They are contained in the following exposition which attempts to follow a logical order and to contain sufficient non-technical matter to permit the layman to skip the technical portions and still find the information he wants.

2. Maps as Distorted Models

The reader might be more willing to accept distortion of hydraulic model scales when he realises that there are other types of model, mostly showing some kind of distortion. Examples are given in Sec. 4. The present section discusses the universally known example of maps of the world. Like all other models they have the following uses:

i. The qualitative use of aiding the mind to visualise a complicated or otherwise not readily visualisable prototype.

ii. The quantitative use of providing numerical answers to questions about the prototype.

The student of elementary geography uses the map model qualitatively. The navigator uses it quantitatively to answer questions such as "How far from A to B by a prescribed route?" "What, and how long, is the shortest route from A to B?" Because their minds have become used to **interpreting** the model —the layman's intuitively, and the navigator's in terms of mathematical laws—neither thinks of the distortion in ordinary use. Yet the distortion is much worse than in a hydraulic model, for a world map represents on a plane the position or points on or near a spheroidal surface that cannot be developed into a plane; thus the distortion varies from point to point and, in Mercator's system of mapping, is so violent at the Poles that these points find themselves translated into lines equal in length to the equator.

The mind accepts map distortion because a map sets points on a piece of paper into **orderly correspondence** with points on the earth's surface. The utility of the map is greater when more is known of the law of correspondence, but may be considerable when little is known. Obviously if nothing were known of the earth there could be no map models; but if nothing were known of cartography as we now understand it, travel on the earth would still be somewhat uncertain. Generally, model science has grown like its special branch, cartography, by comparison of tentative models with prototypes; the object is to devise a model that will have a simple but definite **law of correspondence** with the prototype. There is nothing remarkable in that law requiring unequal scales and, thereby, involving what the layman unfortunately calls "distortion," with its non-technical connotation of "twisting out of proper shape."

3. Definition of a Model

The preceding example suggests a definition of models, in general, that is worth stating before giving further examples. Each example should be checked against the definition. It is:

> A model is a device that attempts to establish an orderly correspondence between its own variables and variables of the prototype.

Notice that this definition permits "distortion" as popularly understood, and does not even require the model to use the same kind of variables as the prototype—for example an electric current could be used to model a fluid discharge.

4. Further Examples of Models

The following examples of various models will emphasise that "distortion" is merely obedience to some kind of law, unless misapplied, and need not be troublesome unless unexpected or misunderstood.

i. **Hobbies Models.** Models made by hobbies' enthusiasts are not usually intended for quantitative measurements, but they may be expected to "work." The constructor of even a static model locomotive or aircraft will usually find that he cannot preserve exact geometric similarity without finding himself involved with ridiculously spindly shafts and struts, or mechanical parts too small to reproduce; working models present further troubles.

ii. **Atomic Models.** The atomic physicist has accustomed himself to a mental model of the atom, in the sense that he does not actually construct one; he uses a planetary system to represent his ideas on the constitution of the atom and reckons that the universe provides the model for him. This kind of model is interesting because it uses the enormous to model the ultra-microscopic. Further, some physicists do not regard the model as representing what the atom looks like; they use it as a means of fixing their ideas about degrees of freedom.

iii. **Prandtl Mixing-Length Model of Turbulence.** A mental model, rather of the atomic type, is implied by the Prandtl mixing-length theory in hydraulics. Nobody knows what turbulence looks like, in detail, but Prandtl chose to represent it by small lumps of fluid starting miraculously to shoot across the general flow and mingling with the flow again after short "mixing-lengths." The implied model is that of molecular motion in a gas, and it has retained popularity and utility, not because it depicts what happens—it fails to do this—but because it provides a visualisable mechanism that could transfer momentum very much as it is really transferred.

iv. **Electric Analogue.** Aspects of the seepage of fluids through fine-grained soils can be studied by electrical methods with marked accuracy and success. It is known that, over a certain range of variables, the behaviour of the fluid flow is represented by the same form of differential equation as applies to flow of electricity through a conducting medium. Suppose that the pressure distribution of subsoil water beneath a weir on permeable foundations is required, and that the conformation of the weir and its pile-lines constitutes boundary conditions for which mathematicians cannot solve the differential equation of flow. (Solutions are available for very simple conditions only.) Then a bakelite (non-conducting) model is made of the weir and pile-lines, in a shallow tray about the size of a kitchen table top. The porous medium is represented by an electrolyte; the fluid surface is re-

Scales for Moving-Bed River Models—continued

presented by copper strips; the " heads " of water upstream are represented by the potentials of the terminals of a battery connected to the strips. The lines of equal electric potential are mapped by means of a probe connected into a suitable electric circuit and correspond to lines of equal hydraulic head in the soil-water; if the electric model shows that the drop of electric potential from the upstream copper strip to a certain point is x per cent. of the battery potential drop, then, at the corresponding point in the hydraulic prototype, the drop in head from upstream is x per cent. of the drop in head over the weir.

This electric model is one of the most successful in hydraulics, though the layman would hardly recognise it as a model at all. It is somewhat special in that it is based on exact information—about the equation of flow—whereas most hydraulic models are based on some degree of ignorance. It might be considered as a calculating machine to solve, by electric means, a differential equation beyond the scope of the mathematican.

v. **Ship Model.** The layman is usually confident in the results of towing-tank tests of model ships because the models are undistorted. He does not know that the towing-force componnets are distorted though the geometry of the model is not. The resistance to motion contains a part A due to wave-making, and a remaining part B due to fluid friction. In the model B may be larger than A; in the prototype A will be larger than B. A is scaled up according to one law—the Froude law; B is scaled up to a very different one found from experiments on flat plates and probably not very accurate for the curved plates of a ship. In fact, the process is — measure the pull on the model at a definite speed, estimate B, deduct B from the pull to give A, scale up A to give its prototype value at the speed of prototype corresponding to model speed, estimate B for prototype, add to get prototype pull.

vi. **Spillway Model.** The overflow spillway model—just a waterfall followed by a rapid—is usually made geometrically similar to the prototype, and will predict the position of the hydraulic jump on the rapid quite well. But suppose the spillway crest is narrower than the river downstream, and that diverging walls are built downstream from the jump in the hope that the water may follow them. Usually the flow will follow such walls only part of the way and then show a preference for one side, so that a jet emerges from the work and may scour an erodible stream-bed and sides. If a model, made of the same material as the prototype, shows that jetting will be moderate then the prototype will usually show severe jetting. The failure of the model to predict jetting intensity correctly arises from the fact that it distorts friction. If a new model is made with the prototype roughnesses scaled down (say by using plastic to represent concrete), in the hope of scaling friction properly, it may still fail because a small model may work in the range of hydraulic behaviour where friction does not depend on the nature of the boundary.

5. Interpretation and Scale Effect

The preceding examples should show that a model, like a work of art, is not a slavish copy but, instead, a representation that requires to be **interpreted.** This interpretation requires knowledge of prototype behaviours and of basic principles that provide rules or laws of correspondence.

Obviously a model-worker who knew all the rules and laws would have little use for models except of the calculating machine type (Sec. 4 iv). Usually he is careful to disclaim omniscience; on the other hand he does not wish to proclaim ignorance. A piece of technical jargon inspired by his second trait is " Scale Effect." A model exhibits scale effect when it does something that was not expected or whose law of correspondence is not known accurately. The jetting in the spillway divergence of Sec. 4 vi provides an example.

6. Dynamical Similarity with Rigid Boundaries

The technical term " dynamical similarity " has been devised for use with rigid-boundary models using simple, as distinct from sediment-bearing, fluids. It implies restrictions too severe for use with mobile-boundary models using fluid that transports sediment. Its utility will be understood from the following solved problem.

" Imagine a body—say a torpedo—that is to be propelled at a great depth in a vast extent of fluid (then its motion does not disturb the surface and there are no solid boundaries but its own to complicate the problem). We wish to discover the resistance to motion at various speeds, V, so that we can design a propelling motor. Suppose we try to derive a formula to give the answer. We can progress only part of the way to a solution. Thus, the resistance is measured by the amount of momentum imparted to the fluid per unit time by the motion of the body. **Provided the flow pattern is fixed** we should expect that, other factors remaining fixed, (i) doubling the fluid density would double the momentum generating rate, (ii) doubling the cross-sectional area would also double it, (iii) doubling the speed would double the quantity of matter displaced per unit time and also double its speed, so would multiply the momentum generating rate by four. The formula indicated by these simple considerations is:

$$F = C\rho A V^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where F is the resistance, ρ is the mass density of the fluid, A is some cross-sectional area of the body, V is the speed of propulsion, and C is a multiplier that requires some more consideration. C will depend on the shape of the body viewed along the direction of motion, on the cross-section measured, and on the units. Therefore if we keep to the same units, C ought to have the same value for all bodies of the same shape moving at the same angle to some axis fixed in the bodies in the same way—say the axis of symmetry — provided, further, that **the flow pattern of the fluid is the same for all.** But for this last proviso C would be constant for similar-shaped bodies moving similarly, and we could make a model, perform a towing test, and find C for the prototype. However, the flow pattern for the one shape of body depends on speed, on size, and on fluid viscosity. At sufficiently low speed, small size, or large viscosity the flow can close neatly behind the body; at sufficiently high speed, large size, or small viscosity, the flow separates from the body to form a " wake," and the point of separation varies with the variables mentioned. So C is far from constant and, in fact, depends on such a complicated flow mechanism that its mathematical form has not been deduced for even such a simple shape as the sphere. Obviously a model would be useless if all we knew was that it would give a C that did not apply to the prototype; so we must try to find at least something about C. Fortunately the physicist, although unable to tell the value of C under varying circumstances for a given shape and orientation, can state the circumstances under which it is the **same in both model and prototype.** (These circumstances are deduced from the commonsense consideration that the units of mass, length and time must appear in the same way on both sides of a physical equation, just as oranges can equal oranges but not apples, and has nothing to do with hydraulics.) These circumstances, in the particular problem, amount to the condition:

$$V_p D_p / \nu_p = V_m D_m / \nu_m \quad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where p and m refer to prototype and model respectively, V is speed of propulsion as before, D is any convenient length in the body, and ν is the kinematic viscosity of the fluid; the values are " corresponding " — i.e. if D_p is the major diameter of the torpedo's cross-section then D_m is the major diameter of the model torpedo's cross-section. Knowing equation (2) we can now make a useful model test to find the prototype resistance at a given speed V_p. All we now have to do is pull the model at a speed V_m given by equation (2), find its C, and then insert that value of C in equation (1) for the prototype."

The reader will appreciate the points of the preceding discussion from a simple worked example. Suppose we make a one-fifth scale model of our torpedo and use it in a wind-tunnel (keeping the model stationary and moving the wind), so that air corresponds to water. The kinematic viscosity of the air might be ten times that of water (air is viscous compared with its weight).

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So we have:

$$D_m = D_p/5 \quad \text{and} \quad \nu_m = 10\nu_p$$

To ensure that C for the prototype is the same as for the model we have to obey equation (2). Using the values just given, this gives:

$$V_p D_p/\nu_p = V_m (D_p/5) / (10\nu_p)$$

$$\text{or} \quad V_m = 50\, V_p \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2a)$$

This relation tells us that the model will be dynamically similar to the prototype if, and only if, the wind is generated at 50 times the speed of the torpedo in the prototype. Notice, particularly, that the model is not dynamically similar merely as a model; **it acquires dynamical similarity by being run properly.**

To prophesy the prototype resistance, write equation (1) for the prototype, again for the model, and divide, getting:

$$\frac{F_p}{F_m} = \frac{C_p \cdot A_p \cdot \rho_p \cdot V_p^2}{C_m \cdot A_m \cdot \rho_m \cdot V_m^2} \quad \ldots\ldots\ldots\ldots\ldots (1a)$$

Because we have run the model to be dynamically similar, C_p/C_m is unity, and we need not worry about the actual value of the two C's. The A ratio is 5 x 5, i.e. the square of the length ratio. The density ratio for water to air would be about 800. The velocity ratio, from equation (2a) is 1/50. So:

$$F_p/F_m = 1.0 \times 25 \times 800/2{,}500 = 8.0$$

That is, the resistance to the prototype will be eight times that to the model.

If, in this example, we had been provided with a curve giving C_p/C_m under all conditions for the given shape of body we could have used equation (1a) without having to obey equation (2a) —i.e. full dynamical similarity would have been unnecessary. If we had another curve, or table, telling us how to allow for shape the model need not even be geometrically similar. This illustrates the point, already made in the preceding general discussion, that **dynamical similarity is imposed as an artifice to remove factors of which we are ignorant.**

The simple example fails to cover a certain point. Suppose the torpedo were near enough to the surface to produce waves. Then equation (2) would not suffice to ensure similarity of flow pattern. The following condition would be required **in addition:**

$$V_m^2/gD_m = V_p^2/gD_p \quad \ldots\ldots\ldots\ldots\ldots (3)$$

Simple algebra shows that, for both (2) and (3) to be satisfied we must have:

$$V_m^3/g\nu_m = V_p^3/g\nu_p$$

which tells us that a different viscosity of fluid would have to be used in the model for every different speed, and would have to be exactly as given by this equation. Fluids with suitable properties are not practically available, so we have to admit that a dynamically similar model of this case is practically impossible. The ship model of Sec. 4, v, illustrates; it is used without dynamical similarity by replacing equation (2) by knowledge of the law of skin friction.

To sum up on the features of dynamical similarity, as illustrated in this section:

i. It comprises geometric and dynamic restrictions that, if imposable on a model, permit certain factors of ignorance to be eliminated from the calculations used in prediction.

ii. The imposition of the dynamical conditions may be impossible.

iii. If a factor of ignorance can be removed, by using suitable information, then a model that does not obey the restrictions of dynamical similarity may still suffice for prediction.

7. Dynamical Dissimilarity of Mobile-Boundary Models

In this section we discuss models of rivers that have the following characteristics:

1. They have built alluvial plains of fine-grained soil by depositing material that they have transported.

2. In doing so they have formed their own channels.

3. Their channel beds are of sand moving in dune formation.

4. Their sides are generally, but not necessarily, cohesive and erodible.

5. They have acquired, in terms of decades or longer, a general stability or regime, about which they fluctuate during shorter time intervals.

Well-known rivers of this type are the Mississippi, Nile, Indus, Yangtze and Ganges; in principle they do not differ from thousands of insignificant rivulets that might be thought of as models of them. They will be called " regime type " rivers hereafter.

In the last section the tacit assumption was made that the modeller could **impose the boundaries according to his own wishes,** which were usually for geometric similarity with the prototype; however, some models, not discussed in this article, are more conveniently made dissimilar. But the modeller **cannot impose the boundaries of a regime type model** arbitrarily. The popular type of query " To what scales are you going to run the model?" is a begging of the question. It would be posed more fairly as " To what scales have you anticipated that the model will run to suit the legitimately imposed conditions?" along with a query about the conditions.

The fact that boundaries cannot be imposed on models against natural laws is well illustrated by the signal failure of engineers to impose their will on the prototypes against those laws. It is obvious to the few who have studied the recent Regime Theory (Bibs. 1-4), devised by engineers who had the special advantage of working with regime canals; these canals, because of constant discharges and lack of meandering, afforded analyseable data from which a new branch of hydraulic science has been built. However, unco-ordinated parts of regime theory results are known —even if subconsciously—to most engineers who have had extensive dealings with regime type rivers. The origins of some of these portions of knowledge are outlined below to illustrate lessons taught more exactly by Regime Theory.

Dredging existing river channels, without other action, has never achieved permanent success; it has always called for permanent dredging. The lesson is:

i. Depth is fixed by natural laws.

Observation of the depths of river arms led to an early appreciation of the fact that large discharge means great depth. One engineering action making use of this is the closure of unimportant arms so as to divert more water into the main navigable arm. Another is to build V-shaped armoured noses to islands so as to divert more water into a channel that needs it. The lesson is:

ii. Depth increases with discharge.

The effect of imposing a narrow width is seen directly in river reaches that are constricted because they fall between relatively inerodible banks. It is seen indirectly at river bends, where the flow concentrates along the concave bank—i.e. becomes effectively constricted—and causes scour. An interesting use of the curvature principle is to construct a curved single jetty from the end of visible land, out through the sand banks at a river's mouth, so that flow impinging on the jetty constricts naturally; the degree of success of the method depends on the relation of the curvature to the natural meander curvature of the river. Later, the engineer may build a parallel jetty so as to canalise the river; the degree of success will depend on whether the imposed width approximates to that required by nature to ensure the depth aimed at. The lesson is:

iii. Reduction of imposed width causes increase of natural depth.

Engineers concerned with routine observations on many rivers collect cross-sections, slopes, and discharges. They learn the following lessons:

iv. Large rivers are relatively shallow compared with width.

v. Large rivers have gentle slopes.

vi. Rivers with coarse material, or a lot of transported material, are relatively shallow.

vii. Coarse material, or a lot of it, is associated with relatively steep slopes.

Scales for Moving-Bed River Models—continued

The reader should ponder, carefully, whether he accepts these lessons; for engineering actions and literature often ignore some of them. For example it is a common error to dam a regime-type river and expect it to run perpetually in a backwater curve into the reservoir instead of ultimately regaining its natural slope drawn back from the forward end of the delta (with possibly disastrous consequences to property upstream of the reservoir); another common error is to expect the river downstream of the dam to retain its old slope instead of scouring (lesson vii) and undermining the spillway foundations.

Regarding the model as a small river, the above lessons show that a model using bed material and side conditions comparable with those occurring in nature must be deep relative to its prototype—i.e. it **must show vertical exaggeration** otherwise it will refuse to remain as constructed. A common mis-statement of model literature is that a model is given vertical exaggeration to make the depths conveniently measurable; the correct statement is that the modeller is thankful that nature imposes vertical exaggeration on his model, for that allows him to have measurable depths.

8. Application of Regime Laws to Non-Tidal Regime River Models

The equations developed below show a theoretical possibility of making a river model geometrically similar with the prototype by distorting the bed material and the shear stress intensity over the sides. However, there are usually practical barriers to this course, so we shall assume that geometric similarity is not feasible. As dynamical similarity is debarred, in consequence, we must, as in the example of Sec. 6, acquire some special knowledge to replace the ignorance that would be permitted by the imposition of dynamical similarity. Regime Theory (Bibs. 1-4) provides exact laws for regime channels of constant discharge and no meandering, and is susceptible to adaptation to rivers, thereby giving the requisite information. With some recent exceptions, these laws have been ignored in Europe and America in favour of repeated trials of unsatisfactory models until one is found that seems to reproduce known history reasonably; it seems that the wastage of time on even small models may be of the order of six to eighteen months. The following very brief outline of the findings of Regime Theory precedes an explanation of its application to design model scales.

The theory defines a bed-factor, b, related to the properties of the bed-load of non-cohesive material, thus:

$$b = V^2/D \quad \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where V is the mean speed of the constant flow, and D is the depth from water surface to the non-cohesive and (apart from dunes) exceedingly level bed. It further defines a **practical** side-factor, s, thus:

$$s = V^3/W \quad \ldots\ldots\ldots\ldots\ldots\ldots (5)$$

where W is the mean width in terms of depth (i.e. WD equals cross-sectional area of flow). If s is multiplied by $\rho^2\nu$, where ρ is the mass density of the fluid and ν is the kinematic viscosity, the resulting quantity is proportional to the square of the tractive force intensity on the sides, **provided the flow there is technically "smooth."** Obviously s cannot exceed an amount corresponding to the ability of the side material to resist erosion, nor fall below an amount corresponding to the stress that would just prevent deposition of transported material to form banks. Upper limits of about 0.10, 0.25, and 0.35 would apply, roughly, to 0.25 mm. grade sand sides below tide level, to silty clay loam, and to glacial till respectively; for rigid materials, e.g. concrete, the limit would be practically infinite and the formula would cease to apply long before it was reached. Prototypes with natural earth sides usually satisfy the condition of technical "smoothness" even though they may look quite rough; rock pitching would not, and equation (5) would not then be suitable for measuring shear stress intensity.

The above equations, with another, lead to the following practical design formulæ:

$$W = \sqrt{bQ/s} \quad \ldots\ldots\ldots\ldots\ldots\ldots (6)$$

$$D = \sqrt[3]{sQ/\nu^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$S = b^{5/6}s^{1/12}Q^{-1/6}/(Cg/\nu^{\frac{1}{2}}) \quad \ldots (8)$$

where Q is the constant discharge, S is channel slope, g is the acceleration of gravity, and C is a constant whose value is irrelevant here.

Suppose now, as a simple example of how to forecast scales, that we want to use 1 cusec to model a regime canal of 10,000 cusecs, using the same b, s and ν as in the prototype. (The method of imposing the same b is not under discussion now.) The model will be regarded as successful if it moves its bed in dune-formation and retains the dimensions to which it is designed —i.e. neither deposits nor scours. It will do this if, like the prototype, it obeys equations (6) to (8). Thus, following the terminology of the worked example in Sec. 6, the width scale is given by:

$$W_m/W_p = (b_m/b_p \cdot Q_m/Q_p \cdot s_p^2/s_m)^{\frac{1}{2}} \quad \ldots\ldots\ldots\ldots (6a)$$

$$= (1 \times 1/10{,}000 \times 1)^{\frac{1}{2}}$$

$$= 1/100$$

To save writing, in future, it is convenient to use a symbolism that writes equation (6a) as:

$$W_{mp} = (bQ/s)^{\frac{1}{2}}_{mp} \quad \ldots\ldots\ldots\ldots (6a)\text{bis.}$$

so that the suffix mp is merely an order to replace every symbol by its m to p ratio. Then the depth scale is

$$D_{mp} = \sqrt[3]{1/10{,}000} = 1/21.5$$

and the slope scale ratio

$$S_{mp} = \sqrt[6]{10{,}000} = 4.64.$$

In words, the model would be made one hundredth full-size in plan, and the sides could be of any material satisfying the condition of technical "smoothness"—practically, we would hardly want to make the model sides erodible, so the material would be chosen inerodible. The depth would then have to be made one twenty-one point five-th of full-size, and the slope 4.64 times that of the prototype; otherwise the model would deposit or scour till it attained these scales. Notice that the vertical exaggeration, which is just the ratio of depth to width scale, is 100/21.5, which equals the slope scale ratio of 4.64. Last century Osborne Reynolds arrived intuitively at the idea that this relation should hold; the next example shows how it is violated when the b and s ratios deviate from unity.

As an example of how to arrange for the preceding channel to be modelled with a fair approximation to geometric similarity, amend the example so that b_{mp} becomes 4.0, and s_{mp} becomes 0.5. The first condition might be imposed by injecting the right concentration of sediment; the second condition is achieved by the width scale. (The reader is warned against imposing such conditions arbitrarily on actual models unless he has experience that will prevent him from wandering into the region of physical conditions not characteristic of the prototype.) Then, using equations (6) to (8) exactly as before:

$$(W:D:S)_{mp} = (4 \times 1/10{,}000 \times 2)^{\frac{1}{2}} : (\tfrac{1}{2} \times 1/10{,}000 \times \tfrac{1}{1^6})^{\frac{1}{3}} : (4^{5/6} \times (\tfrac{1}{2})^{1/12} \times 10{,}000^{1/6})$$

$$= 1/35.2 : 1/68.5 : 13.9$$

The vertical exaggeration now comes to 35.2/68.5 or only 0.52 times against the previous 4.64 times; but the slope exaggeration has to be 13.9, so that a longitudinal section of the channel drawn to scale would no longer be exactly similar to the longitudinal section of the prototype.

Algebraically, the calculation of river model scales can be performed exactly as just done for the hypothetical canal models. This process is recommended by the writer, and by Sir Claude Inglis in Bib. 2, and seems to be receiving unofficial use in the U.S.A. Bib. 1 attempts to justify the procedure physically.

Scales for Moving-Bed River Models—continued

Briefly, the physical laws underlying equations (6) — (8) for regime canals are operative in regime rivers; therefore the equations may be expected to apply to these rivers if Q is taken to mean a representative discharge—say maximum recorded flood—and multipliers are given to each equation to allow for factors such as hydrograph form, meander pattern, and nature of sides. To eliminate the unknown coefficients when calculating model scales the model is devised to have the same coefficients; this is achieved by using the prototype hydrograph for tests, imposing geometric similarity in plan, and using side material of proper nature. With tidal models additional cognisance must be taken of the tidal equations, see Sec. 9.

Fig. 1 plots the depth against the length scales of the trial-and-error models tabulated in Donovan Lee's " Dock and Harbour Authority " article of June, 1949, and some from the U.S.A. (see Table 1). If the regime theory application advocated here is correct, then the relation of depth to length scale should be given by eliminating Q from equations (6) and (7), to get:

$$D_{mp}^{w} = (S^2/l^3)_{mp}.W_{mp}^2 \quad \ldots\ldots\ldots\ldots\ldots\ldots (9)$$

It will be seen that the model scales are consistent with the regime laws with the $(s^{2/3}/b)$ ratio near enough to that of the prototype to make the introduction of different physical conditions unlikely. In particular the line $D_{pm} = W_{pm}^{2/3}$, often quoted as an empirical rule, but really equation (9) with the s, b term made unity, is seen to be quite a good average representation of what modellers are forced to do in the way of finding scales by trial and error. Of course, Fig. 1 does not prove regime theory; but if the theory were badly wrong such a figure, using an adequate miscellany of data, would be expected to contradict it. The reader who wishes to discuss individual points of the diagram should bear in mind that some so-called mobile-bed models are little more than rigid-boundary models using very fine material, whose object is to deposit in slack-water zones to indicate where shoaling would occur in a regime-type prototype; they will give good results ignoring regime theory unless called on to prophesy about coarse bed-material movement. Other models required to prophesy stage relations and nothing more could be equally well of rigid boundary.

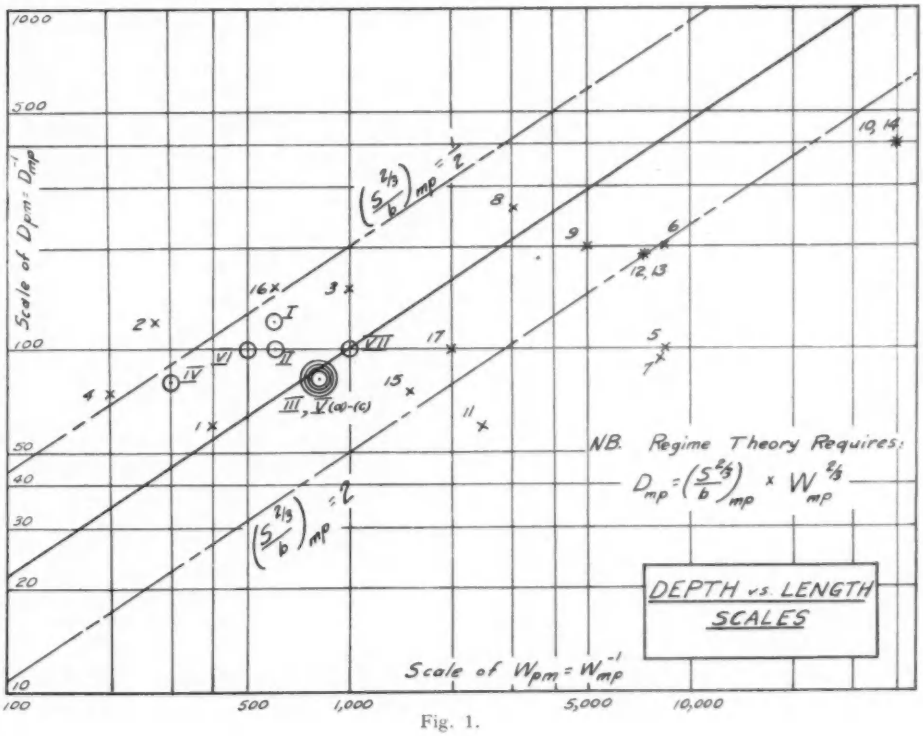

Fig. 1.

9. Tidal Model Scales

In the " Dock and Harbour Authority " of January, 1949, Dr. Doodson criticised the indiscriminate use of distorted scales for tidal models. His method of analysis is used below to show that, over a considerable range of variation of cross-sectional form from place to place in a river, distortion according to regime laws should be permissible under the following limitations:

i. The bed-factor must be the same in model and prototype.

ii. Apparently the side-factor should be kept the same in model and prototype if the viscosity remains the same; otherwise the ratio s^3/v should be kept the same.

The first limitation is definite; the second arises from an engineering approximation in the equation of motion and may be subject to secondary modification.

Before proceeding to proof, a digression is needed for the reader who is uncertain of the meaning of time scale. Imposition or anticipation of time scale is really another way of imposing or anticipating velocity scale. Thus, referring to equation (3), (Sec. 6), and its context, it is seen that, for the particular geometrically similar model to run with dynamical similarity when its length scale has been decided, it must run with a velocity scale given by that equation. The velocity scale is V_m/V_p —or V_{pm} in the nomenclature of Sec. 8. If a particle moves from an arbitrary point in the prototype, through a distance L_p with constant speed V_p, it takes a time $T_p = (L/V)_p$. For the corresponding particle in the model the time to trace the corresponding path with the corresponding speed is $T_m = (L/V)_m$. So the time scale is just :

$$T_{rp} = (L/V)_{mr}$$

TABLE 1.

POINT	TIDAL OR NOT	LOCATION OF PROTOTYPE	W_{pm}	D_{pm}	REMARKS
1	T	Zeebrugge	400	60	
2	T	Abidjan	270	120	See Donovan Lee in "Dock & Harbour Authority," June, 1949 for original data:
3	T	Hook of Holland	1,000	150	
4	T	Wilhelmshaven	200	75	
5	T	Severn	8,500	100	
6	T	Ditto	8,500	200	
7	T	Rangoon	8,060	192	
8	T	Parrett	3,000	260	
9	T	Cheshire Dee	5,000	200	
10	T	Ditto	40,000	400	
11	T	Great Ouse	2,500	60	
12	T	Humber	7,040	192	
13	T	Mersey	7,040	190	
14	T	Seine	40,000	400	U.S. WATERWAYS EXPT. STATION TEC. MEMO No.
15	T	Penang, Malaya	1,500	75	
16	T	Prai, Malaya	600	150	
17	?	Mississippi	2,000	100	
I	N	Mississippi	600	120	110-1 /1938
II	N	Mississippi	600	100	159-1 /1940
III	T	Galveston Bay, Texas	800	80	127-1 /1940
IV	N	Ohio River	300	80	181-1 /1941
V(a)	T	Delaware River	800	80	194-1 /1942
V(b)	T	Ditto	Ditto		2-231 /1947
V(c)	T	Ditto	Ditto		2-259 /1948
VI	T	Abescon Inlet, N.J.	500	100	204-1 /1943
VII	T	St. John's River	1,000	100	2-244 /1947

Scales for Moving-Bed River Models—continued

Usually, with rigid models, the discharge is constant so there is no particular need for thinking in terms of time. A river model has to be run through a sequence of discharges that occupy a definite time in the prototype—say a tidal period, or a year for a hydrograph; to think in terms of speeds would be very awkward, but to think in terms of the model time corresponding to prototype time is simple and convenient. Equations (6) and (7) can be made to show that, for regime conditions:

$$V_{mp} = (bsQ)^{\frac{1}{6}}_{mp}$$

so that the time scale must be:

$$T_{mp} = (W/V)_{mp} = (bQ/s^2)^{\frac{1}{3}}_{mp} \quad \ldots\ldots\ldots\ldots(10)$$

in which the length scale is taken as that of W, since all distances in plan are scaled in the same ratio.

Now consider a tide moving along a natural river channel whose sectional form does not vary too abruptly. (The mathematical discussion of this limitation of " not too abrupt " is difficult and will be found in such advanced texts as Lamb's Hydrodynamics.) At some time, t, let us focus attention on what is happening at a section, distant x from some arbitrary origin. Fig. 2 shows an imagined sectional form (exaggerated vertically to make drawing clearer), with the tide standing at a height ζ above the mean tidal position for the discharge supposed to be coming down the river from above the tidal reach—later in the day ζ would become negative. We suppose that, when there is no tide, the river runs at speed U, with every particle of the section having the same speed at the same time, in accordance with usual tidal theory and not in strict accordance with facts, the L-section of Fig. 2 indicates this speed U and draws a short portion of the water-surface with very exaggerated slope to suggest that the tide is running up against the stream; for the ensuing argument, however, relative directions are immaterial so long as the equations are written for the particular diagram drawn. The tidal current that would occur in the absence of U is taken to be u. The depth of water is measured conventionally in terms of cross-sectional area of flow divided by surface width; at no tide it is h, and at any tide ζ is taken, nearly enough, as $\zeta + h$, so that the assumption implied is that the breadth at full tide is not appreciably different from that at low tide.

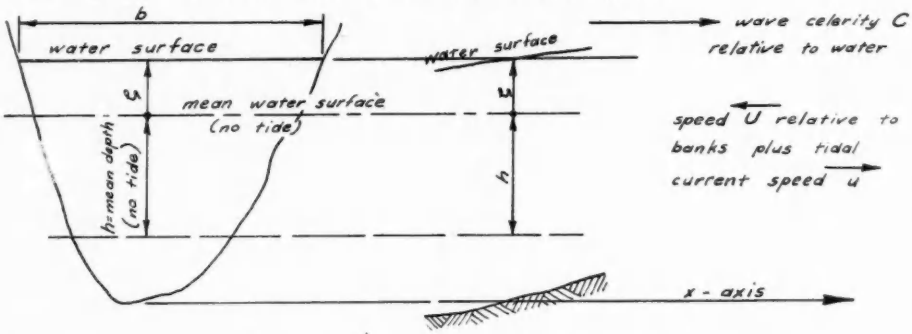
b
water surface
water surface
wave celerity C relative to water
ζ
mean water surface (no tide)
h
h=mean depth (no tide)
speed U relative to banks plus tidal current speed u
x - axis
SECTION at TIME t at x
LONGTITUDINAL VIEW at TIME t of CHANNEL NEAR x
vertical scales greatly exaggerated

Fig. 2.

Two equations are relevant to the problem. The first is the equation of continuity, that expresses the indestructibility and incompressibility of the fluid used. The continuity equation, given in a more general form than in Dr. Doodson's article is:

$$\frac{\partial \zeta}{\partial t} = -\frac{1}{b} \cdot \frac{\partial}{\partial x}\left\{b(h+\zeta)u\right\} \qquad (1)$$

Suppose it is written for the prototype. Let all horizontal dimensions of the model be X times the corresponding dimensions of the prototype, and let Y and T apply similarly to vertical dimensions and to times. Then, for the model, the equation of continuity becomes:

$$\frac{\partial \cdot Y\zeta}{\partial \cdot Tt} = -\frac{1}{Xb} \cdot \frac{\partial}{\partial \cdot Xx}\left\{Xb(Yh + Y\zeta)\cdot\frac{Xu}{T}\right\} \qquad (2)$$

which is just:

$$\left(\frac{Y}{T}\right)\cdot\frac{\partial \zeta}{\partial t} = \left(\frac{Y}{T}\right)\left[-\frac{1}{b}\cdot\frac{\partial}{\partial x}\left\{b(h+\zeta)u\right\}\right] \qquad (3)$$

So we see that, if some particular functional relation between the variables of the continuity equation expresses the solution for the prototype, exactly the same expression is correct when the corresponding variables of the model are inserted instead. So there is nothing wrong with arbitrary distortion of scales so far as continuity is concerned.

The equation of motion is the second relevant one. Written for the direction of flow—nearly horizontal—it is:

$$\frac{\partial u}{\partial t} = -g\frac{\partial \zeta}{\partial x} - u\frac{\partial u}{\partial x} - C\frac{(u-U)|u-U|}{(h+\zeta)^{1.5}}\cdot\left(\frac{vs}{b^2}\right)^{\frac{1}{4}} \qquad (4)$$

(a) = (b) + (c) + (d)

If the term (d) is omitted, the equation is the conventional one of tidal theory, without friction, when amplitude may be large compared with depth. If (c), also, is omitted, the equation is the standard one for tides of small amplitude.

The term (d) is not dynamically unassailable. It is just gS (i.e. force per unit mass) taken from the regime flow formula:

$$V = \text{const}(D/vs)^{\frac{1}{4}}/b)^{\frac{1}{2}}\sqrt{2gDS}.$$

Dr. Doodson, in the article quoted, took gS from the Chezy formula. If the writer knew no regime theory he would have taken gS from the Manning formula, since it allows for the Chezy " constant " being far from constant. The basic point to notice is that, irrespective of particular formulæ the term (d) is borrowed from the gross flow in a complete channel section under **uniform conditions,** and applied in an equation relating to particles and for **non-uniform** conditions. As no formula is known for non-uniform conditions, and the experts still argue about the best one for uniform ones, this is still the best we can do under the circumstances; and it works remarkably well in calculating backwater curves.

Taking term (d) for what it is worth, and inserting model dimensions in the equation of motion, just as was done with the equation of continuity, the result is:

$$\frac{X}{T}(a) = \frac{Y}{X}\cdot(b) + \frac{X}{T^2}(c) + \frac{X^2}{Y^{3/2}T^2}\cdot\left(\frac{vs}{b^2}\right)^{\frac{1}{4}}_{mp}(d)$$

Obviously the insertion of model dimensions in the solution of the differential equation for the prototype will not, in general, produce a solution. However, if it proves possible to equate the various multipliers of (a), (b), (c), (d), then the scales derived by this process will permit a solution.

Suppose first that friction is negligible, so that term (d) vanishes. Then we require to equate:

$$(X/T^2) \text{ to } Y/X$$

giving

$$(X/T)^2/Y = 1.0 \quad \ldots\ldots\ldots\ldots\ldots(11)$$

This just requires that:

$$(V^2/D)_{mp} = b_{mp} = 1.0 \quad \ldots\ldots\ldots\ldots\ldots(12)$$

This is the condition (i) stated at the start of this Section as an essential for the variables of the model to be related by the same functional expression as the variables of the prototype.

If friction is important, then term (d) must be included, and it requires the additional condition:

$$Y/X = (1y^{\frac{1}{4}})\cdot(vs/b^2)^{\frac{1}{4}}_{mp}$$

Scales for Moving-Bed River Models—continued

which can be squared and, with $b_{mp} = 1.0$, written as

$$(vs)^{\frac{1}{2}}_{mp} \cdot X^2 = Y^3$$

Equation (9) (Sec. 8), with $b_{mp} = 1.0$, allows this to be further simplified to:

$$(vs)^{\frac{1}{2}}_{mp} = s^{\frac{2}{3}}_{mp}$$

or

$$s_{mp} = v^{\frac{1}{2}}_{mp} \quad \ldots\ldots\ldots\ldots\ldots\ldots (13)$$

This is the condition (ii) stated at the start of the Section. Considering that its derivation is not as rigid as for the first condition, we may say that the practical indication is to keep s about the same in model and prototype. Of course, the preceding analysis does not show, without more work, how badly one might deviate from ideal conditions before a model for a particular purpose would start to predict unreliably.

10. Answers to Queries

The reader may prefer to answer the queries of the Introduction for himself. Possible correct answers are summarised below:

1. By obeying natural laws that produce the same kind of distortion in prototypes of different sizes. (Sec. 7.)
2. To obey nature, see above.
3. Geometric similarity is necessary for dynamical similarity; but dynamical similarity is a special condition imposed on certain models to eliminate unknown factors (Sec.6). Lack of that special kind of similarity does not imply dynamical impossibility.
4. To permit the same bed-factor to be given to the model as to the prototype; a different bed-factor would result in wrong scaling of tides (Sec. 9).
5. See Sec. 9, equation (10), with b and s the same as in prototype, equation (7) of Sec. 8 shows that the time scale is the same as the depth scale.
6. Yes. See answer iv.
7. See Sec. 8.
8. Because the model is tidal it has to follow the Froude criterion (Sec. 9, eqn. (12)) in respect to depth. It does not follow the Reynold's criterion for either depth or width; it imposes the same tractive force intensity on the sides as occurs in the prototype.

11. Practical Modelling

This article has confined itself to the problem of scaling models that, above all other considerations, are required to reproduce the physical conditions of prototype bed-movement correctly. Such models, like the geometrically-similar rigid-boundary ship and spillway models of Sec. 4, cannot be expected to reproduce correctly all the prototype conditions that might occur in practice. In particular they may be expected to show quantitative inaccuracies for phenomena related to rigid works built in a river. These inaccuracies can be kept within reasonable bounds by limiting vertical exaggeration, that is by using a large enough discharge scale (Sec. 8, eqns. (6), (7), and ensuing example); hence the use of large outdoor models in preference to the tiny ones possible in the laborotary. These residual inaccuracies must be dealt with by skilled interpretation. It follows that a knowledge of up-to-date theory is not sufficient in itself for practical modelling. A model should be a co-operative effort, combining knowledge of hydraulics, models and prototypes, not usually found in a single individual.

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Chamber of Shipping of the United Kingdom

Excerpts from Annual Report, 1950-51

The first section of the Report reviews the main events, both international and domestic, which have engaged the attention of the Chamber of Shipping during the year. It deals, among other things, with the impact on shipping of the international situation; the domestic crises brought about by a shortage of coal and competing priorities in import programmes; it indicates how penal taxation is hampering the replacement of ships, and how Government trading seriously interferes with the normal machinery of world trade. The following paragraphs from this section are of importance to a number of readers of this Journal.

PORTS POLICY

The over-riding consideration which has actuated the whole policy of shipowners with regard to ports has been the desire to secure the best and most up-to-date port facilities consistent with economical efficiency. The Industry has sought to co-operate to the fullest extent with the British Transport Commission and the Docks and Inland Waterways Executive but has been disturbed by what appears to be a tendency in the preparation of "Harbour Schemes" to favour central control in port administration and to under-rate the expert views of the actual users of the ports. As in other matters with which they are concerned, the views of shipowners are determined by hard practical considerations. The severe school of experience and not of theoretical planning has imparted the lessons against which the shipowner judges such schemes.

There is a danger that port administration may become more a subject of controversy than of co-operation.

TURN-ROUND IN PORTS

Delays in ports throughout the world remain one of the major items in increased operating costs. Slow turn round of expensive modern ships is a waste of transport at a time when this can be ill afforded in the national interest.

In particular cases, Liner companies have had to put surcharges on their rates to try to meet the extra costs. Tramp shipowners tend to avoid those ports where restrictive or discriminatory practices, or "slow-motion" work hold up loading and discharging. These seem to be the only means by which shipowners can to some extent protect themselves.

As far as U.K. ports are concerned—and, let it be said, although not the best they certainly are not the worst—the limitation on capital development and on reconstruction has undoubedly hampered their progress towards increased efficiency. As pointed out in the Report of the British Transport Commission for 1948, the Commission owns and controls no less than 30 per cent. of the port facilities of Great Britain. In view of the Shipping Industry the Commission would best serve the interests of the nation in general and shipowners in particular by concentrating upon securing the maximum efficiency at those ports. The improved competitive ability of the Commission ports is more likely to promote efficiency at other ports than any extension of the British Transport Commission's ownership and control of ports.

The section dealing with Departmental matters gives a comprehensive record of the tasks which the Chamber has carried out in the past twelve months, and, inter alia, draws attention to some of the problems facing U.K. ports.

PORT FACILITIES

Although remaining of the opinion that it was a mistake to bring port matters within the scope of the responsibilities of a body principally concerned with the nationalised inland transport system, the Industry, under the guidance of the Ports Committee, has continued to do all it can to assist the British Transport Commission and the Docks and Inland Waterways Executive in their task of keeping the United Kingdom "trade harbours" under review and in the preparation of schemes.

The last Annual Report recorded the nature of alternative proposals put forward by the Docks Executive in relation to (a) the

Chamber of Shipping of the United Kingdom—continued

Tees and Hartlepools, and (b) the Clyde area. In October the Docks Executive promoted a provisional scheme for the Tees and Hartlepools which appeared to confirm the apprehension of the industry that developments were tending to lead to an extension of ownership of port facilities by the Transport Commission with control of administration in London. The Docks Executive have also announced their intention of promoting a scheme for the port of Aberdeen, and alternative proposals similar to those described in the last Annual Report, were advanced for discussion.

These developments proved disturbing and the Council of the Chamber, at its December, 1950, meeting, adopted the following Resolution :—

" This meeting of the Council of the Chamber of Shipping of the United Kingdom :—

(i) regrets to note from recent negotiations with the Docks Executive, particularly in relation to the Provisional Scheme for the Tees and Hartlepools, a tendency for that Executive to favour an extension of the British Transport Commission's ownership and administration of ports and to advocate central control in port administration ;

(ii) deplores the disposition of the Docks Executive to underrate the importance of the advice given by the bodies which, under the provisions of the Transport Act, have to be consulted in the preparation of Harbour Schemes ;

(iii) re-affirms its conviction that the provision of the most up-to-date efficient and economical ports will, in general, and where practicable, be secured through locally autonomous Public Trusts on the lines of those operating several of the major ports."

In their rejoinder to the Resolution, the Commission expressed their awareness of, but did not accept, the contention of the Shipping Industry that port administration could in general best be provided by locally autonomous public trusts. They denied that the draft scheme for the Tees and Hartlepools implied a tendency to favour an extension of ownership and central control of ports by the Commission; re-affirmed previous statements that the Commission and the Docks Executive would deal with each scheme on merits and claimed that the advice tendered " by all the parties consulted " in relation to the Tees and Hartlepools scheme disclosed " such wide divergencies " that it was impossible for the Commission to accept all of it, and that it was therefore unreasonable to suggest that any particular advice had been under-rated.

This reply was disappointing. While the Chamber was glad to have a renewed assurance that each harbour scheme would be considered on its merits, the fact remains that in all the proposals so far emanating from the Docks Executive, the emphasis has been on ownership by the Commission and upon an increased measure of control by that body.

The statement by the Commission that there are differing views on the Tees and Hartlepools scheme is understandable if only by reason of the substantial representation of the servants of the Commission on at least two of the bodies. But so far as the Chamber is aware, the organisations speaking for the users of the ports as well as those who provide the greater part of the facilities, other than those owned by the Commission have declared their opposition to the principle of centralized control and to certain other main features of the provisional scheme.

The Chamber has maintained that shipowners must be made aware of the nature of the " wide divergencies " of views claimed by the Commission if there is to be effective consultation with them as users of the ports, in accordance with the terms of the Transport Act. In its view, the consultative provisions of that Act require that, in the preparation of harbour schemes, the maximum guidance should be given by, and that, at least, a substantial measure of general agreement should be reached with the interests concerned, viz., those providing the existing port facilities, the users of the ports, and the worker employed in them.

In its submissions on the provisional scheme for the Tees and Hartlepools, the General Council of British Shipping renewed an earlier suggestion that a small number of representatives of these main interests should meet together in an endeavour to establish the greatest possible identity of views.

Early in 1950 the Docks Executive completed its review of the larger ports not owned by the Commission. The reason for not including the commission-owned ports within the scope of the review is not readily appreciated; ownership of them clearly provides the Executive with all the information it requires as to their physical characteristics, but the views of users of those ports would, no doubt, be of assistance in determining what steps, if any, should be taken to improve their efficiency and economy. A review of the smaller ports has been commenced, the Cumberland ports having been visited in July. In connection with all these visits, the Chamber has been active in co-ordinating the views of shipping interests.

Other matters which have engaged the attention of the Ports Committee during the year under review were: the Middlesborough Dock improvement scheme, and the delay in developing the facilities under the Tees Conservancy Commission at Lackenby; the transfer of Southampton Docks from the control of the Railway Executive to the Docks Executive; the Report of the Working Party on Increased Mechanisation in Ports; the new oil wharves in Southampton Water; Private Bills and Provisional Orders dealing with port facilities and port charges; and the future of the small port of Whitstable, threatened by a proposal to close the branch railway line serving it.

DOCK CHARGES

The last Annual Report recorded the proposal of the British Transport Commission to increase the charges at the late railway and canal ports. After a full inquiry, at which the Chamber, through the Traders' Docks and Harbour Co-ordinating Committee appeared by counsel, the Transport Tribunal reported in favour of the proposal and the increases—general level from 75 per cent. to 100 per cent. above pre-war and the surcharge on coasting traffic from 25 per cent. to 50 per cent.—became operative as from 15th May. It is satisfactory to record that during the inquiry, the Commission agreed to accede to the Chamber's submission that traffic between the United Kingdom and Eire should revert to the coasting status which it enjoyed prior to 1947.

A number of other applications for authority to increase port charges has been dealt with through the Traders' Dock and Harbour Co-ordinating Committee including a proposal by the Mersey Docks and Harbour Board to re-impose town dues on coastwise exports which was successfully resisted.

POLLUTION OF SEA WATER BY OIL

The problem of the pollution of sea water by oil has, after an interval of some ten years, again been considered on an international level, this time by the Transport and Communications Commission of the United Nations. A number of questions relating to the problem were circulated to member governments to obtain their views both on the appropriate procedure to be followed in drawing up an international convention and on the substance of such a convention.

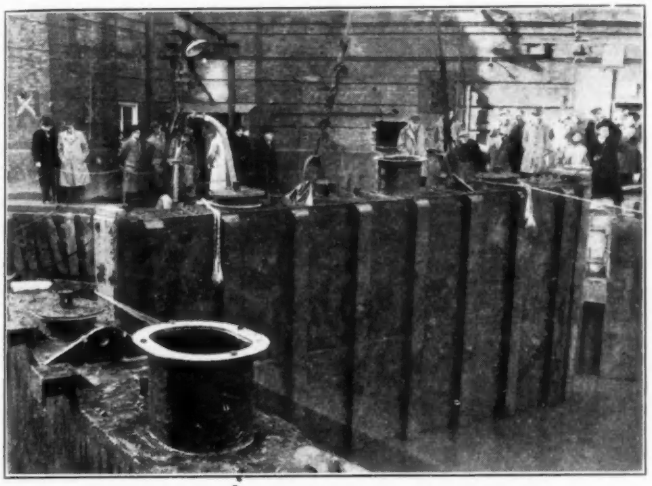
The Chamber has had discussions with the Ministry of Transport and other interests concerned in order to formulate agreed answers to these questions. In the course of these discussions, it was agreed that the Inter-Governmental Maritime Consultative Organization, if and when it was set up, would be the appropriate body to deal with the problem. The Chamber has undertaken to assist the Ministry in the compilation of information relating to the separator facilities at ports and on ships. The positon of coasters, upon whom a statutory prohibition of discharge within 50 miles of the coast would bear unreasonably, will require special consideration.

NEW SYDNEY BRIDGE.

A contract for the erection of a new £A600,000 steel bridge in North Sydney over the Middle Harbour at The Split has been awarded to the Cleveland Bridge and Engineering Co. Limited, Darlington, Co. Durham. The work, which is expected to take four years to complete, will comprise six spans of 100-ft. with a bascule opening span. There will be four traffic lanes and two footways.

New Dock Gates for Hay's Wharf, London

A new pair of Welded Dock Gates with electrically operated machinery have been designed and built for the Proprietors of Hay's Wharf Ltd., London. The gates which are for a 40-ft. entrance and weigh 26 tons per leaf, were fabricated at the Teesdale Works of Head, Wrightson & Co., Ltd., delivered to Hay's Wharf as ship's cargo and transferred to the actual site by a 60-ton floating crane owned by the Port of London Authority. This crane was also used for placing the gates into position, and a feature of the operation was that both leaves were stepped in one tide.



View of Second Gate being stepped into position.

Both gates finally stepped, with P.L.A. 60-ton Floating Crane in background.

Each leaf of the gates consists of nine plate ribs, the alternate members being fitted with flange plates. The skin plating is lap jointed to these flange plates and is composed of four strakes on the flat and curved sides. The ribs are stiffened by angles, the toes of which are welded directly to the web plates and skin plating. Vertical stiffness is provided by two plate diaphragms extending for the full depth of the gate leaf. The heel post and mitre post are built from plates welded in the form of channel and joist sections respectively. A central core plate, with stiffener brackets at deck centres is welded directly to the web of the heel post. The Greenheart mitre post and sill timbers are made in one piece, the heel post timber being made in two pieces. Each gate leaf is held in position by two anchor rods with washer plates, one rod being set normal to the line of the dock, the other 90° to this.

The gates are operated by electrically driven machinery working from a 5 b.h.p. 1410 r.p.m. motor. All intermediate gearing is completely enclosed the final drive passing from a vertical worm reducer to the rack pinion. A horizontal rack which is directly connected to a rolled section conveys the actuating force to a bracket attached to the top of the skin plating. Situated in this arm is a shock absorber which is made double acting by the judicious use of a helical compression spring. The actuating arm is housed on horizontal supporting rollers when the gate is in the open position. Limit switches are arranged to cut out the motor at the appropriate time, and overload release is provided by oil dashpots to safeguard the machinery in the event of obstruction during the course of operation. Any tendency to over-run or creep is prevented by the inclusion of an electro-magnetic brake situated between the motor and the first reduction box. The operation of the gates is fully automatic by push button control from either side of the dock, provision being made for independent operation of each leaf or the simultaneous operation of the two leaves. Provision is also made for emergency hand operation in the event of a failure in the electrical supply.

Book Reviews

Prestressed Concrete. By Professor G. Magnel. Second edition. 300 pages. 268 illustrations. Price 15s. (London : Concrete Publications, Ltd.).

Developments in prestressed concrete have made necessary a new edition of this well-known book only two years after it first appeared. The second edition contains 80 more pages and 100 more illustrations of prestressed concrete structures. New matter includes the design and construction of multiple-storey framed buildings, continuous beams, and several bridges including a continuous-girder bridge of two spans of 207-ft. with complete calculations. In addition to the author's simple semi-graphical method of design, there is an improved method for the design of the ends of beams. Theoretical matter is supported by numerous tests, including a test to destruction of a bridge girder of 155-ft. span, tests on the ends of beams, on the fatigue of wire, and on the buckling of prestressed concrete rings. The section on precast prestressed concrete products has been much enlarged to include detailed descriptions of the latest methods of manufacture.

Myhre's Handbook of Baltic and White Sea Loading Ports. The 10th Edition of this Handbook, consisting of 1,096 pages which have been thoroughly revised and extended, has now been published, and can be obtained from J. Jorgensen and Co., Copenhagen.

In present times with declining freight rates, it is of the utmost importance that economy be studied, consequently, it is imperative for shipowners to know the conditions prevailing, the expenses which will be incurred, and to have these effectively checked by the captains.

The latest Edition contains full particulars of Harbour conditions and facilities, Pilotage and towage, Port charges and all other Expenses, Stevedoring Prices, and Lists of Shipbrokers, Stevedores and Shippers. It also gives the fullest information about port and loading places in Sweden, Finland, Russia, White Sea, Denmark, Norway and the Netherlands, besides up to date information on Poland and Germany. In addition, the chapter on the United Kingdom has been considerably enlarged. Furthermore the 10th Edition has been supplied with an extra section embracing information with regard to the freight forwarding conditions at all the important airports in countries covered by the handbook.

For almost 40 years the usefulness of the handbook has been amply justified, and has proved that its cost is always compensated by expenses saved through the information contained. The book is of great value to Shipowners, Brokers, and Captains, and will afford the greatest assistance to all interested in the Baltic, White Sea and North Sea Trades.

CONFERENCE OF WESTERN EUROPEAN PORTS.

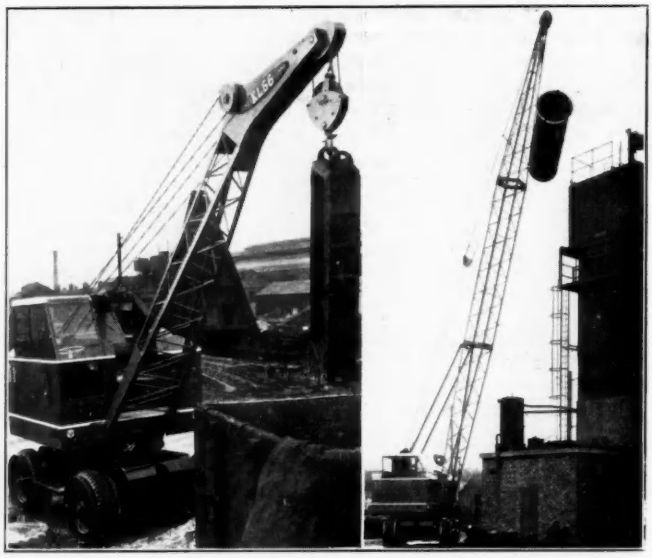
An international conference of Western European port and harbour authorities is to be held this spring with the object of bringing about closer co-operation in the matter of Rhine shipping.

Manufacturers Announcements

A New Heavy Mobile Crane

British mobile crane design, already ahead of foreign competitors, has been given a still greater lead by the introduction of a new 6-ton crane known as the Jones KL 66. This machine is, in fact, unique in its class. Designed and made by K. & L. Steelfounders & Engineers Ltd., of Letchworth, who are members of the 600 Group of Companies, it embodies a number of new and original features aimed to meet the diverse and often arduous duties demanded by an ever increasing variety of users. Whilst high speeds are required for duties such as grabbing and magnet operation, other duties such as the handling of fragile merchandise, or the accurate placing of masonry and structural members in building and civil engineering demand great sensitivity of control. The KL 66 is designed to satisfy both extremes of duty with equal efficiency and with a degree of reliability hitherto unknown.

The controls of this crane are simple in operation and are so placed as to avoid fatigue to the driver. There are only three foot pedals (for engine-clutch, travelling brake and engine speed respectively), and steering is by a large diameter steering wheel, set at the optimum angle for easy manipulation. The levers are light in operation and are placed conveniently to hand so that any



KL66 Crane with standard 20-ft. jib and (right) 60-ft. lattice construction jib.

chance of confusion is avoided. The weatherproof saloon cab has large safety-glass windows all round which give an exceptionally wide range of vision. A cab heater for use in cold weather can be fitted if required.

The crane is the full-circle slewing type and, in common with the existing range of Jones KL Mobile Cranes, uses the direct mechanical transmission system with Diesel prime mover. The four motions of hoisting, slewing, travelling and derricking are independently operated and reversible.

A new feature, the advantages of which will be readily appreciated by engineers, is the application of unit construction to the various crane motions. Each motion—e.g. hoisting, slewing, derricking and travelling—has its own gearbox with enclosed bearings and gears with oilbath lubrication. The hoisting and derricking brakes, which are semi-automatic in operation, are arranged for manual adjustment without tools, in order to facilitate and encourage regular attention.

The maximum load of six tons can be hoisted at speeds up to 40-ft. per minute, but lighter loads up to two tons can be handled at 120-ft. per minute, enabling high outputs to be attained when the crane is used for grabbing. For accurate placing of loads, an inching movement is provided, either for lifting or lowering, by a small movement of the joy-stick type lever.

The crane slews on a large diameter ring of live-rollers, which give extremely smooth action. The slewing speed is variable up to 2½ r.p.m. in either direction and slewing can be carried out simultaneously with hoisting if this is desired for fast operation. The derricking gear, which is completely independent of the other motions, will raise the jib, with load if necessary, from maximum to minimum radius in 20 seconds.

Whilst the normal crane motions—i.e. hoist, slew and derrick—are very impressive, it is perhaps in its travelling abilities that the machine is outstanding. Gradients up to 1 in 8 can be negotiated by the machine travelling light; and a full load of six tons can be carried on level ground at speeds of up to three miles an hour. Without loads, on level ground, the crane can travel at six miles an hour and can turn in a circle of 23-ft. radius. Travelling speed is operated by accelerator pedal, and a large plate clutch in conjunction with a three-speed gearbox gives extremely smooth and flexible control. Brakes of Girling 2-leading shoe type are fitted on all four travelling wheels, which makes for maximum safety under all road conditions. The brakes are operated by foot pedal and a hand lever is provided for parking.

Pneumatic tyres are employed on restrictor wheels of special design which are slightly smaller in overall diameter than the tyres. Such wheels have many proven advantages. They limit deflection of the tyres when slewing and thus obviate instability which might arise if, for example, the tyres were under-inflated. They provide a large additional bearing area which prevents the cranes from sinking in soft ground. They protect the side walls of the tyres from damage when the crane is working in, say, steel stockyards, scrap yards, or alongside the kerb. Finally, in the event of a sudden blow-out the restrictor wheels take the weight immediately, so avoiding what might be a serious accident.

The standard power unit is a Perkins Diesel engine of 37 b.h.p., fitted with maximum speed governor in addition to the variable speed control operated by the accelerator pedal in the driver's cab. Electric self-starting is fitted as standard equipment and thermostatic control of the cooling system keeps the engine at the correct running temperature whatever the climatic conditions. The engine is arranged as a completely self-contained unit so that alternative makes of engine can be fitted to meet customers' special requirements.

The crane can be supplied as a mobile crane on pneumatic tyred restrictor wheels or on crawler chassis. It is also available as a lorry mounted crane or on railway chassis. If required, it can be supplied on a fixed base suitable for mounting on a platform or wharf.

The general dimensions of the crane are as follows :—

Overall width : 8-ft.

Overall height with jib lowered : 11-ft. 4-in.

Tail radius : 6-ft. 3-in.

Weight with 20-ft. standard jib : approx. 13½ tons.

Stability margin on level ground : not less than 50%.

The maximum duty of the crane is six tons at 9-ft. radius with proportionately smaller loads at longer radii, full details of which can be obtained from the makers.

Publication Received

NEW DESIGN RENOLD CHAIN CLUTCH.

We have received from The Renold and Coventry Chain Company Limited, Manchester, a leaflet giving applicational data and installation and erection instructions on the revised design of the Renold Chain Clutch. It is claimed that the new design is unique in that it has a greater power transmitting capacity in relation to its size than any other clutch. It is designed for incorporation with a chain-wheel and can be fitted on either "driver" or "driven" shaft. It can be supplied to operate with equal efficiency as a clutch coupling for co-axial shafts, or for use with belt or gear drives. Copies of the leaflet are available on request.